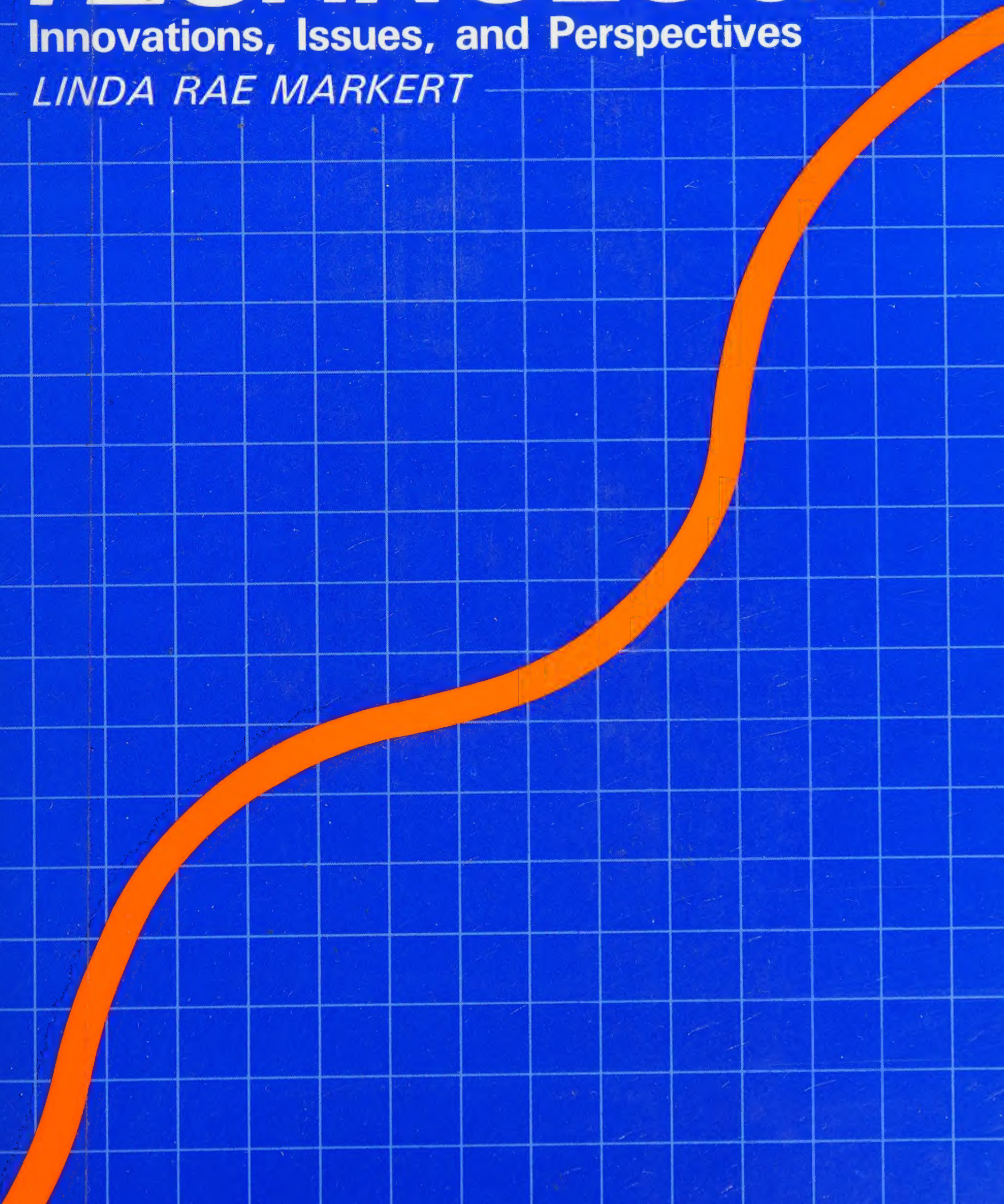
CONTEMPORARY TECHNOLOGY

Innovations, Issues, and Perspectives

LINDA RAE MARKERT



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Innovations, Issues, and Perspectives

by

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INTRODUCTION

CONTEMPORARY TECHNOLOGY: Innovations, Issues, and Perspectives is written for college and university courses related to technology and society. It is intended to introduce you to the pervasive nature of technological innovations and to increase your awareness of both the promises and the uncertainties associated with the use of technology as a creative human enterprise.

The chapters are organized under three subheadings. Section I, Innovations, contains six chapters that discuss recent developments and breakthroughs in the following technical disciplines: genetic engineering, artificial intelligence, communication, space exploration, medicine, and manufacturing. Section II, Issues, includes four chapters that focus on some of the public controversies associated with significant issues in technology transfer, energy resources, environmental policy, and defense strategy. The final three chapters make up Section III, Perspectives, and address sociological viewpoints regarding our effective use of technology and the projected stability of our "pseudo traditional" social institutions.

CONTEMPORARY TECHNOLOGY presents technical facts and figures in a general way to provide you with an overview of the innovations, issues, and perspectives on the topic of technology. It is impossible, in these few pages, to cover all the bases, investigate all the angles, or delve into all of the topics with the thoroughness desired. This book will prove to be a useful starting point in your study of technology and its impact on society. The text raises issues, pro and con, to be considered in the application or use of technology. The lengthy reference list at the end of each chapter will provide you with suggested readings for further study or research in areas of particular interest.

It is the author's desire that the course or activity for which you are reading CONTEMPORARY TECHNOLOGY will "teach" you to think, analyze, cricitize, and ultimately search out new sources of information. It is also the author's primary objective to motivate you to take an active role and participate in current and future technological ventures.

Linda Rae Markert

About the author . . .

Dr. Linda Rae Markert is well qualified to write CONTEMPORARY TECHNOLOGY. As a professor in the Division of Technology at San Jose State University, she developed and teaches the basic Technology and Civilization course, as well as numerous graphics and professional courses. Her teaching experience coupled with various papers presented to industry and education keep her up to date with the field and a sought after speaker. Dr. Markert's educational degrees include a Bachelor of Science from the State University of New York at Oswego, a Master of Science from Illinois State University at Normal, and a Doctor of Education from the University of the Pacific. Her most recent honor was being named the Outstanding Professor of Industrial Technology by the National Association of Industrial Technology. Working and teaching in San Jose keeps Dr. Markert in touch with high-tech industry and trends in technology.

The Publisher

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Chapter 1

DEVELOPING A TECHNOLOGICAL VOCABULARY

DATELINE

Stockholm, Sweden

For some 13 years, a Swedish business consultant by the name of Ulf af Trolle worked on writing a book. The 250-page manuscript contained his recommendations on strategies Swedish companies could use to solve their economic problems. At this point, it appears that it might take him another 13 years to piece it back together.

A Stockholm daily newspaper, the Aftonbladet, disclosed that Mr. af Trolle shipped the completed manuscript to a copying company shortly after the final draft was finished. It seems an employee at the copy house confused a paper shredder with a copying machine. A few weeks later, the author was informed his manuscript had been sliced into thousands of very thin strips.

Apparently, af Trolle had no backup copy and he decided to hire a number of school-age youngsters to piece the book back together. Mathematicians estimated the project could take years. . . .

INTRODUCTION

What better way to open the first chapter of a book about contemporary technology than to relate a fairly insignificant incident about one person's dependence on a modern by-product of technology. Further, this individual's misfortune may sound highly improbable, possibly a touch absurd and even a bit humorous to most of you who have just started reading this book. At least a few of you must certainly be thinking, who could ever mistake a paper shredder for a copying machine? It is quite conceivable the author of the economics manuscript was forced to wonder the very same thing! After all, electrostatic copiers have been around for years and most people, that you know, use them without a second thought. Although paper shredders are not quite as common, they obviously bear very little resemblance to an office copying machine.

From a different perspective, this calamitous tale about technology brings to mind another series of questions. Who would believe a writer would deposit his or her *only copy* of a manuscript with a group of strangers? Doesn't it seem odd the author did not have a "back-up" copy of his material? Even if the manuscript had not been prepared on a word processor, a typewritten carbon copy should have been reserved in case of any sort of accident. We are living in a world where computerized information storage and retrieval systems have become the rule rather than the exception.

Many of us have actually become quite accustomed to the idea of record-keeping redundancy in our lifetime. All kinds of personal statistics, credit references, academic records, annual earnings figures, and health reports are stored electronically by any number of agencies around the world. These bits and bytes of what was once considered to be "private" information are transmitted back and forth between and among banks, universities, government offices, and detective agencies in a matter of a few seconds. For a while, it seemed as if the grand advancements in communications technology would result in what literary observers called a "paperless society." To date, not many people seem willing to completely relinquish their right to have a "hard copy" of any document being reviewed. In fact, the advent of computerized information systems coupled with the ever present electrostatic copier has led to a society more "full" of paper as opposed to one that uses "less" of it.

Unlike the distressed author in the opening DATELINE story, most people insist on having multiple copies of everything they write or transcribe for someone else. This oversimplified example of contemporary daily living illustrates the point that technology pervades every business and every individual's life. For this reason, it is no longer possible, if indeed it ever was, to be casual about science and technology. Large and small, banal and impressive, scientific innovations and technological improvements pour out at an increasingly accelerated rate of speed. A great portion of such technological change, modification, and improvement is hardly even noticed these days. Many of us have become numb to novelty unless it is formidable, majestic, or entertaining in its outward appearance.

The types of breakthroughs receiving the greatest amount of media attention and the subsequent interest of the public seem to take place most often under the guise of exotic new "high-tech" industries. Among these disciplines one might list: biotechnology, computers, robotics, artificial intelligence, lunar mining, fiber optics, pharmaceuticals, supersonic transport, lasers, glass ceramics, satellites, space shuttles, and so forth. Behind all the glitter of high-tech, we find a gamut of new, but also unremarkable technologies that cut across a wide range of businesses including: sporting goods, convenience foods, household appliances, tools and gadgets, children's toys (often enjoyed by adults too!), video games, soft drinks, music, art, and the like. In other words, contemporary science and technological advances range from tiny improvements in devices that we take for granted (e.g., coated frying pans, or the shape of the knobs on the TV set), to heroic leaps forward that have far-reaching impacts on the status of life on the planet (e.g., nuclear weapons, space stations, and artificial organs).

Who among us though has the authority to say that any one of these changes is any more or any less important than any other? That is one of the most rhetorical questions of the era! Technologies that one social group favors are simultaneously abhorred by other groups. Some persons' lives are hanging in the balance of whether or not a medical breakthrough will be made before it's too late. Others believe too much money is already being spent on medical research which only benefits those who can afford it. Some people profess to be anti-technologists, while others are avid supporters of technology. Still more persons find themselves somewhere along this continuum of extremes. Before we go any further, it seems essential that we stop and think about what these central terms imply, or how they can best be defined.

THE NATURE OF SCIENCE AND TECHNOLOGY

Over the past several decades, academic leaders around the world have developed a well-regarded discipline given the label "Science, Technology & Society" (STS). Through curricular proposals, scholarly papers, annual conferences, and hundreds of articles and books, these professionals have garnered a great deal of respect for an area of study that is, in every sense of the word, interdisciplinary. Its principles, theories and objectives pervade the many circles of physical scientists, life scientists, humanists, business analysts, educational specialists, engineers, and industrial technologists. One of the aims of STS research has been to investigate the relationships (both historical and contemporary) between science and technology in an attempt to reveal how the developments in both fields influence the nature of social institutions.

CAN TECHNOLOGY BE DEFINED?

The word "define" is a variant of the Latin term "definire" which translates to mean "to set bounds to." In order to define a word or concept, one must therefore be able to delimit its meaning through the establishment of boundaries. A definition not only explains the true or accepted meaning of a term, but it also delineates what is *not* true about it. In this day and age, technology is one of those words (like engineering) that has been used, overused, and misused to the extent that it almost defies definition! If one has difficulty explaining what technology is *not,* then it must be everything else. By definition, a definition should *exclude* something—it can not include everything. This surely sounds like a quagmire of semantics!

In many cases, the word technology has become so diluted that a secondary modifier is demanded for further clarification. Thus we have expressions such as: medical technology, military technology, household technology, manufacturing technology, communications technology, computer technology, agricultural technology, industrial technology, and so on. The list continues as a greater number of specialized permutations (ordered arrangement) become evident. From this perspective, technology seems to make reference to the procedures and artifacts that are aligned with a particular discipline. On the other hand, the degree to which the research foundations for each discipline are interrelated makes it hard to say exactly where an exclusive product of technology fits. For example, is a solar-heated grain elevator part of agricultural technology, or, does it belong under the energy technology heading, or, even the manufacturing technology category? Modifiers enable us to focus on a certain discipline, but they do not really define the term technology very effectively.

It has become fashionable to abbreviate the term technology to its shortened "tech" version. There is high-tech, low-tech, and no-tech these days. We also use the prefix "techno" to refer to a host of social conditions such as: technophobia, technostress, technocrat, technotoys, technoworld, technodummies, technowizards, technolifestyle, and you name it. Once again, since we have become conditioned to these modern day expressions, they are implicit in their use. Each of these terms has something to do with either the *level* of technological development or society's *behavioral* or *psychological response* to technology.

Perhaps it is easier to explain the meaning of technology by generating a list of its profile characteristics. Let's try that together. As you review the following inventory, place a check mark next to any features you honestly believe are *not* true about this concept.

1. Technology is a powerful force that improves human productivity.
2. Technology is an extension of human physiological capabilities and biological potential.
3. Technology involves inventing new things and modifying the old ones to make them more efficient.
4. Technology is evident in every culture regardless of its level of sophistication or stage of development.
5. Technology creates new economic opportunities and, at the same time, new social problems.
6. Technology enables humans to exert control over the natural environment.
7. Technology liberates us from demeaning and demanding labor and therefore creates more leisure.
8. Technology has increased the human life span by conquering many debilitating diseases.
9. Technology incorporates human knowledge into physical hardware which will eventually respond to some human need or desire.
10. Technology is applied science.
11. Technology is a process for transforming raw materials into useful goods and services.

12. Technology is man-made.
13. Technology creates uselessness by displacing people and trivializing their work.
14. Technology has made many persons apprehensive about the future.
15. Technology is fundamental to the survival of mankind.
16. Technology is destructive to nature.
17. Technology is making the world increasingly incomprehensible.
18. Technology is future-oriented and therefore progressive.
19. Technology is motivated by a pragmatic (practical) or instrumental interest.
20. Technology utilizes the methods, tools, and skills typically characteristic of the process we call innovation.

Now, if you made a number of check marks in the margin as you scanned through this very partial list of modern technology's features, go back to those items and read them over a second time. While there is definitely a thread of deception to each of these ideas, cogent (convincing) examples can also be cited to validate every one of them. Technology is not a simple word to define. It is used over and over again in this book within a whole series of contextual arrangements. Since the purpose of this chapter is to get you started toward the development of a technological vocabulary (a set of terms and definitions), let us try to reach some sort of agreement. The following simple definition is not any more correct or useful than any other, but it can be used to establish boundaries.

Technology is the cumulative sum of man-made means used to satisfy human needs and desires and to solve specific problems in any given discipline.

IS SCIENCE DIFFERENT FROM TECHNOLOGY?

The terms science and technology are so routinely combined to form a single phrase that some people find it nearly impossible to distinguish between the two. What is scientific is also perceived to be technological and vice versa. It was not always this way. For centuries, people regarded science and technology as distinct fields of study entirely separate from one another. SCIENCE was understood to be the pursuit of knowledge that would enhance human understanding of the natural environment. TECHNOLOGY simply entailed making things and inventing other things that humans could use to control or cope with the natural environment. In other words, early scientists were not often concerned with practical applications of the knowledge they secured and early technologists did not have the need to understand the reasons things worked the way they did.

Therefore, one of the early distinctions between science and technology made reference to the world of "know-what" and "know-why" on the one hand, and the world of "know-how" on the other. Throughout the 20th century, the line between scientific inquiry and technological application has become quite obscure. In fact, one of the chief characteristics of contemporary technology is that it is based more and more on the scientific knowledge of the nature of things, why materials react in certain ways, and which laws are in force at any given point in the process of development. Some excellent examples of "science-based" technology are found in atomic energy, fiber optics, biotechnology, antibiotics, and microengineering. The traditional language that clearly distinguishes science from technology is beginning to break down.

Contemporary scientists are still motivated by curiosity, but they also recognize the need for the results of their research to be industrially relevant. In this regard, a recent strategy among the scientific community has been an attempt to establish that a close link exists, via technology, between pure science and its application to economic ends. Thus, science is what is, while technology is what can be as a result of science. Stated differently, scientists have been anxious to demonstrate their apparently curiosity-oriented work would, ultimately, lead to critical profit-making technological innovations and business ventures. This book reveals numerous instances where this strategy has been quite successful. In sum, it is difficult to separate science from technology. To simplify the confusion, the following explanation for this term is proposed.

Science is a stream of man-made events involving a mathematical or systematic study of nature which results in a body of knowledge that is practical as well as theoretical.

OVERVIEW OF THE TEXT

The following thirteen chapters are organized under three subheadings. Section I, entitled INNOVATIONS, contains six chapters that discuss and explain recent developments in the following technical fields: genetic engineering, artificial intelligence, communications, space exploration, medicine, and manufacturing. These areas have been selected to illustrate the dynamic interaction between and among seemingly disparate fields of specialization.

Section II, ISSUES, includes four chapters that focus on the dilemmas and controversies that are commonly associated with technological change. The subject areas that have received a significant amount of public attention during recent years are presented here as issues in: technology transfer, energy resources, environmental protection/degradation, and defense strategy.

The final segment of the text is Section III, PERSPECTIVES, and it contains three chapters that address sociological viewpoints regarding the effective utilization of technology and the projected stability of our traditional social institutions.

The format for each chapter is consistent throughout the book. As you found with this first entry, each chapter opens with a DATELINE incident which is in some way pertinent to the subject matter covered. These brief "contemporary historical vignettes" are designed to illustrate that technology marches on throughout the world at all levels of fascination, without the least regard for time. They are meant to show you that a simple glance through today's newspaper or last week's national magazine will reveal some event (major or minor) in technology that is already or will soon be shaping the way we live each day. As you read through each chapter, a reference will be made back to the DATELINE to tie it into the material being discussed.

Technical facts and figures are presented in a general way in this book. Highly respected publications and entire series have been written on each and every topic contained here. This fact alone makes it a challenge to provide a brief "overview" that makes any sense. Informed readers will unquestionably react to this author's method of content coverage by saying something like: "the author left this out;" "the author forgot to mention that important historical fact;" "the author doesn't provide enough examples to back up her ideas;" and so forth. For this very reason, a lengthy reference list of suggested readings for further study is provided at the end of each chapter. Your ongoing perusal of technical subject matter either directly related to your career objectives or indirectly supportive of them is strongly recommended. Several publications to which you might want to consider opening a subscription to in the future include: *Technology Review, Discover, High Technology, Wall Street Journal, Science, The Futurist, Science Digest, Scientific American, OMNI, Harvard Business Review* and *Fortune.* While this list is not exhaustive of the titles available, it is a representative sampling which is highly readable and quite informative for English-speaking individuals. The discussion questions found at the end of each chapter are designed to stimulate further creative thinking about the innovations, issues and/or perspectives presented under each of the major subject headings. It is impossible for any one author or solitary instructor to cover all the bases or investigate all the angles—you must take some personal responsibility for the learning endeavor.

Toward this end, it is essential to recognize the development of a technological vocabulary goes far beyond a rote memorization of terms and their meanings. If the formal study or informal activity for which you are using this book "teaches" you anything, it should teach you how to think, learn, and search out new sources of information. No single reference is ever completely infallible. A technological vocabulary changes and expands on a regular basis. In just a few years, a whole new set of terms will be "on the books" but not included on the following list. This introductory glossary offers brief explanations for many of the terms and phrases listed under the KEY CONCEPTS segment of each chapter. Note that the chapter where the term or phrase will be studied is referenced below.

A GLOSSARY OF TECHNOLOGY TERMS AND CONSTRUCTS

Agrigenetics: [C-2] Research and development efforts in the biotechnology industry that seek to modify various plants and animal species to either make them resistant to natural predators or impregnate them with specific genetic traits.

Agroforestry: [C-10] A technology management strategy that proposes creative farming techniques that combine trees (forest preservation) with other crops or livestock.

Amniocentesis: [C-6] A medical test normally performed during a woman's 16th week of pregnancy to determine if the unborn child has certain birth defects. Amniotic fluid is withdrawn through a thin hollow needle inserted through the abdomen. Fetal cells are then cultured in the laboratory and chromosomes are carefully studied. Results are available in 3-5 weeks. Accuracy of the chromosome results is greater than 99.5%.

Anthropomorphism: [C-3] The act of imparting "lifelike" or human attributes to inanimate objects. It also denotes the ascription of human feelings and emotions to nonhuman beings.

Appropriate Technology (A.T.): [C-8] An intermediate level of technology development vs. one too sophisticated or complex for the problem in question. A.T. is also an attitude regarding an overreliance on high technology. A.T. refers to technology that "fits" the cultural situation for which it is proposed without causing more problems than it solves.

Artificial Intelligence: [C-3] A subfield of computer science that studies the use of computers in the execution of tasks that are normally considered to require higher level cognitive abilities (e.g., perception, learning from mistakes, reasoning, and understanding).

Balloon Therapy: [C-6] Formally referred to as balloon angioplasty. It is a medical procedure which has the potential to replace coronary by-pass surgery for clearing out clogged arteries.

Bar Coding: [C-7] A primary component of automatic identification systems in industry. The bar code industry uses several different code languages or symbologies for which uniform symbol descriptions have been published. Each code is generally made up of binary digits where bars and spaces in different configurations represent numbers, letters or other symbols. The code is scanned and transmitted directly into a computer to identify the part or product.

Bioastronautics: [C-5] Quite simply, the study of life in space. How do living organisms adapt to conditions of weightlessness and then re-adapt to life on earth? What sorts of technological innovations can be envisioned to make this cycle occur more smoothly?

Biological Containment: [C-2] A self-regulating policy used in genetic engineering research. It prescribes (1) the use of bacterial hosts too weak to survive outside the laboratory, and (2) experimentation with microorganisms which can only grow in certain hosts that are predictable. It is a method employed to prevent an accidental "environmental release."

Biological Warfare (BW): [C-11] The use of a living organism, usually a pathogenic (capable of causing disease) microorganism (protozoa. fungus, bacteria, virus), for hostile purposes.

Biomass Energy: [C-9] An alternative energy resource that makes use of organic plant matter and animal waste to create heat energy or useful fuels such as methane gas and ethanol.

Bioprocessing Technology: [C-2] Bioprocesses are systems in which complete living cells or their components, such as enzymes or chloroplasts, are used to effect desired physical or chemical changes. In genetic engineering, bioprocess technology will enable biological methods of production to be adapted for large scale industrial volumes.

Breeder Reactor: [C-9] A nuclear reactor that generates fissionable fuel (plutonium-239) by bombarding appropriate nuclei (uranium-238) with neutrons during the routine operation of the reactor. The doubling time is the length of time it takes to produce twice as many plutonium atoms as fissionable atoms that were present when the reactor started operating. This figure is dependent upon the design of the reactor. A very efficient breeder reactor might have a doubling time of about six years which means it would produce enough fuel to refuel itself and another similar reactor after six years of operation.

''C^{3}I:'' [C-11] Pronounced "see-cubed-eye," a military acronym for Command, Control, Communications, and Intelligence. This is a U.S. Department of Defense research project that envisions the establishment of a powerful computerized network to control the nation's nuclear forces in the absence of human beings.

Cell Fusion: [C-2] Involves the artificial joining of cells to combine the desirable characteristics of different types of cells into one cell. This union is known as a hybridoma.

Cellular Telephone Network: [C-4] Cellular technology uses an advanced network of low power transmission and reception sites that form a group of adjacent cells. These cells are linked by actual telephone lines; signals are switched by a computer and connected directly into the local phone system. The network enables callers to place and receive calls from a mobile unit such as an automobile.

Computer Blacklists: [C-4] Databases containing the names and identification codes for individuals who should not be given credit, an automobile insurance policy, or whatever due to some legal problem in their past. These are regularly compiled and updated by financial institutions and government agencies, etc. This form of electronic record keeping has caused many persons to question their rights to privacy.

Computer Integrated Manufacturing (CIM): [C-7] The umbrella acronym (pronounced "sim") for a host of automation technologies in the manufacturing environment. It does not refer to *one* specific technology, but to the integrated use of computers in *all* sections of enterprise, from the planning of production, through the design and manufacture of a product, up to the assurance of good quality.

Content Analysis: [C-14] A forecasting technique where reviewers keep a close track of events as they happen in order to make an accurate projection of major trends 1-2 years down the line. Content analysis often makes use of daily newspapers as its primary source of reference material. It had its roots among military strategists during World War II.

Creationism: [C-13] A theological doctrine that ascribes the origin of all matter and living forms as they now exist to distinct acts of creation by God. Creationists generally refute theories of evolution which hold that mankind evolved biologically from a less sophisticated species.

Cybernetics: [C-3] A term often used to label computer science curricula. It is the theoretical study of control processes in electronic, mathematical, and biological systems. It is uniquely descriptive of the mathematical analysis of the flow of information through these systems.

DARPA: [C-3] Acronym for Defense Advanced Research Projects Agency. It was established by the U.S. Department of Defense in the late 1950s. It regularly funds research projects in high tech fields, most notably that of artificial intelligence at the present time.

Decoys & Chaff: [C-11] Terms used to describe penetration aids that are included in the deployment of nuclear missiles. Decoys are dummy warheads which look like the real thing but carry no explosive power. Chaff consists of thin, confetti-like metallic strips that are released to confuse the opponent's radar system.

Delphi Study: [C-14] A forecasting strategy whereby a group of pre-selected "experts" engage in an anonymous exchange of opinions through an intermediary who controls the feedback of ideas in sequential rounds of interchange. There is a tendency, over time, toward a converging consensus among the group members.

Demand Lag: [C-8] Related to the rate of diffusion of technologies being transferred. After the technology is first introduced into the innovating country's domestic markets, how long does it take for it to gain acceptance in foreign markets?

Diagnosis Related Groups (DRG): [C-6] Written into federal law in the early 1980s as the funding mechanism of Medicare. Adopted as a payment scheme, DRGs work this way: After a patient has been diagnosed, the hospital receives a fixed fee reflecting an average cost of curing that condition. If the patient is worse than average, the hospital must pay any cost beyond the DRG allowance. If the patient is better than average, the hospital keeps any money left over.

Direct Broadcast Satellites (DBS): [C-4] These satellites can broadcast a television signal directly to small antennas at home or work. The signal can carry multiplexed digital information which characterizes its teletext potential. Teletext refers to computerized information and entertainment systems that use a normal television signal to distribute the data to television sets or monitors.

Durational Expectancy: [C-12] A concept introduced by Alvin Toffler in his *Future Shock*. It refers to a culturally-based attitude or expectation regarding how long things are usually supposed to last. When these expectancies are disrupted, people are forced to cope with unplanned changes.

E. Coli: [C-2] An abbreviation for the single-celled bacterium called Escherichia coli that is commonly found in the human intestinal tract. It is used in recombinant DNA research because of the ease with which it can be engineered. E. coli bacteria reproduce themselves every 25 minutes even after their genetic code has been altered via splicing.

Electronic Cottage: [C-4] A term that was first coined by Alvin Toffler in his publication *The Third Wave*. It refers to a social phenomenon where people spend more time working in their homes instead of going out to the office or the factory. It has given rise to a new form of working labeled "telecommuting" where persons can work at home on personal computers that are connected via telecommunications equipment to the corporate office.

Electrophoresis: [C-5] A space age manufacturing technique that enables materials to be separated in solution by subjecting them to an electrical field inside a restrictive chamber. The Z-gravity environment in space accelerates and improves the process by allowing the mixture to flow continuously.

Environmental Analysis: [C-10] The process of conducting a comprehensive study and review of a broad range of environmental features such as topography, hydrology, geology, and cultural status for a specified land area. The results of this study can aid a developer in selecting an appropriate site to purchase and develop while using a plan that is environmentally sound.

Environmental Release: [C-2] As a generic concept, this refers to the accidental or deliberate release of a contained substance into the natural ecosystem (air, land, water). It represents a central point of debate in genetic engineering experiments where genetically altered organisms are allowed to be tested outside the laboratory.

Epidemiology: [C-14] The systematic study of widespread epidemics (contagious diseases) or physiological maladies which have reached epidemic proportions. Medical researchers often use laboratory animals in this field of research as it relates to risk assessment for the human population.

ERIS: [C-11] Military acronym for Exo-atmospheric Re-entry vehicle Interceptor Subsystem. It is a ground-based weapon capable of intercepting and destroying incoming warheads above the earth's atmosphere.

Evapotranspiration: [C-10] A naturally occurring process akin to the earth's tropical forests and their role in global climate management. As tropical forests respirate, they release moisture into the air which later accounts for certain rainfall patterns. Depletion of the forests could result in a drying out of the equatorial region and a northward shift of agricultural lands.

Expendable Launchers: [C-5] Throw-away booster rockets that are used to launch payloads into an Earth orbit. The word expendable means they burn up after they are disengaged from their cargo. The leading candidates to be the United State's expendable launch vehicles include the Delta, Atlas, and Titan rockets.

Expert System: [C-3] An intelligent computer program that uses knowledge and inference procedures to solve problems challenging enough to require a significant amount of human expertise for their solution. Expert systems portray a model of the expertise of the best minds in a particular discipline (medicine, prospecting, air traffic control).

False Positives/Negatives: [C-6] A negative side-effect associated with the purchase of self-diagnostic kits for use in the home. These may occur when the user does not perform the test correctly or misinterprets the results and finds, erroneously, that he/she *does* have a particular symptom or *does not* have the condition for which the test is being administered.

Fiber Optics: [C-4] A technology that converts data, sound, or images to light impulses which are propelled by a laser across a thin strand of glass at very high speeds. Many of these glass threads are bundled together and buried in the ground or hung from existing power or telephone lines.

First Strike: [C-11] Generally refers to a disarming attack on the enemy. Land-based MIRVed missiles are very accurate — they are excellent first strike weapons that can be used to destroy the opponent's missiles before they are even launched. They are also quite vulnerable. "Second strike" refers to the retaliatory efforts of the opponent using any arms that survived the first strike.

Flexible Manufacturing Systems (FMS): [C-7] A fully automated, computer controlled production system offering substantial advantages in comparison to the conventional job shop. An FMS is a set of machines linked by a material handling system — all are under central computer control. Flexible machining centers (cells) can produce a variety of parts by a simple change of software. They also allow multiple operations to be performed on a workpiece.

Futures Wheel: [C-14] A forecasting technique first devised by the World Future Society. It entails a small-group brainstorming session where the participants examine interrelated chains of events that might be consequential to a particular social trend or technology.

Gene Therapy: [C-2] A field of study in health science which researchers hope will enable them to cure diseases genetically transmitted from one generation to the next. The procedure entails transplanting healthy genes into the cells of patients who are suffering from disabling diseases in an attempt to increase their chances for survival or decrease the chance that the defect will be passed on to their progeny.

Geostationary Orbit: [C-5] A geosynchronous orbit that is approximately 22,000 miles away from the earth's surface. Satellites in this orbit move at the same speed of the earth's rotation. Thus they are always in the same position over the one spot of the earth's surface.

Greenhouse Effect: [C-10] The heating up of the earth's surface due to increased levels of carbon dioxide in the upper atmosphere which traps solar energy. This phenomenon is also called global warming. It has dramatic ramifications with reference to the stability of the planet's ecosystem.

Group Technology (GT): [C-7] An approach to manufacturing that segregates parts according to their design or manufacturing characteristics. When similar parts are gathered together, each group can share set-ups and machine tools which reduces the cost of production. A GT database is a computerized filing system that enhances the efficiency of work performed in manufacturing cells.

Health Maintenance Organization (HMO): [C-6] An HMO is essentially a merger of an insurer and a provider of health care. They are an alternative to traditional fee-for-service providers. They utilize a fixed payment medical plan by representing a prospective payment on an annual basis. In the HMO form of managed care, consumers buy memberships; when ill, they go to HMO-run clinics to see physicians who are salaried employees. As long as members stay within the HMO sphere, they spend little or nothing beyond the annual fee.

Heuristics: [C-3] These are rules of thumb based on a compilation of personal experiences over time. They are used to help guide problem solving exercises. In the field of artificial intelligence, heuristics are built into computer programs to enable machines to make educated guesses. Unlike algorithms (mathematical computation), they do not guarantee a solution.

IAEA: [C-9] International Atomic Energy Association. Established in the early

1960s to set up international nuclear safety standards and generally support and encourage nuclear energy research projects.

IEA: [C-9] International Energy Agency — formed in 1974 in response to international concern for unstable oil prices and supplies. It was set up under the auspices of the OECD (Organization for Economic Cooperation and Development) but without the participation of France. IEA established an oil-sharing system which could be automatically triggered by another member nation if its oil supplies fell 7 percent or more short of its normal level. They also required member countries to maintain a 90-day emergency oil reserve which could be used to cushion any oil supply disruption.

Imitation Lag: [C-8] Related to the rate of diffusion of technologies being transferred. After the lead nation begins producing a new device, how long does it take for other countries to obtain the production capabilities to produce the same product?

In Vitro Fertilization: [C-6] A procreation option for child-bearing couples who are unable to conceive in the conventional method of intercourse. Eggs are removed from the woman's ovaries and fertilized outside her body by the father's sperm in a laboratory dish. The fertilized egg is then reimplanted in the woman's uterus.

Industrial Robot: [C-7] A reprogrammable machine designed to handle materials or tools in the performance of a variety of tasks. Reprogrammability is what makes the industrial robot different from so-called hard automation which does not allow for easy changes.

Inference Engine: [C-3] The control structure component in a computerized expert system. It is a universal (not locked into one specific knowledge base) problem-solving paradigm (pattern) commonly involving chaining of if-then rules to formulate a useful line of reasoning.

Interactive Video: [C-4] A form of teleconferencing or telecommunications technology where system users have the ability to add interactive foreground annotation (notes) to any background image on the screen. Conferees at the receiving end can see the results on their screen. Educational software programs are commonly interactive allowing students to enter a response and receive real-time feedback regarding their performance.

Intergeneric Organism: [C-2] A new organism that is a result of the deliberate combination of genetic material from cells in different (two or more) species.

Just-in-Time (JIT): [C-7] A manufacturing philosophy that attempts to eliminate all non-value adding operations, equipment, and resources. JIT eliminates waste throughout the system including inventory at both ends of production, and all machinery and manpower that do not contribute directly to the product. JIT had its roots in the Japanese automobile industry.

LISP: [C-3] Acronym for List Processing Language. It is a common artificial intelligence programming language being widely used. LISP programs and data are forms of symbolic expressions stored as list structures. LISP deals then with two kinds of objects: atoms and lists. *Atoms* are symbols used as identifiers to name numeric and/or non-numeric objects. A *list* is a sequence of zero or more elements enclosed in a defined set.

Lithotripter: [C-6] A device that supports an emerging noninvasive medical technology. It is a machine which uses sound waves to destroy kidney stones from outside a person's body.

Local Area Networks (LANs): [C-4] A network of cables and switching boxes providing high-speed data communication links between and among computers or computerized machines that are operating in the same geographic area.

Manufacturing Automation Protocol (MAP): [C-7] Developed by General Motors, MAP is a purchase specification that can provide standardized communications links between automated equipment in the CIM environment. Once installed, files, messages and control strategies can be transferred over MAP so any piece of gear can talk to any other piece of gear.

MIRACL: [C-11] Military acronym for Mid InfraRed Advanced Chemical Laser. It was initially developed for the U.S. Navy to determine whether or not lasers could knock down missiles aimed at ships. A very large laser, its ability to project an intense beam of heat and light against distant targets makes the chemical laser a candidate to destroy incoming ICBMs. Its use as a space-based weapon in the SDI is unlikely due to the huge optical system needed to insure its accuracy.

MIRV: [C-11] Military acronym for Multiple Independently Targetable Reentry Vehicle. This technological feature allows one rocket to deliver several warheads with great accuracy to different targets. It was first developed in the United States to overwhelm a Soviet ABM (anti-ballistic missile) system.

Modern Environmentalism: [C-10] A term used to describe an information-based perspective supporting the need for harmony and balance between industrial objectives and environmental protection.

Monoclonal Antibodies: [C-2] Antibodies are proteins in the blood stream generated by an organism's immune system in reaction to foreign proteins and polysaccharides. They neutralize the foreign agents and produce immunity against certain microorganisms or their toxins. Monoclonals are produced by the clones of a single hybridoma cell. A hybridoma is a modified cell resulting from the fusion of two different types of cells. They are homogeneous and their production is predictable and repeatable. Monoclonal antibodies can potentially be used to diagnose diseases and purify proteins.

Mutual Assured Destruction (MAD): [C-11] A military defense policy which attempts to deter opponents from a first strike against each other. Where both sides have the ability to absorb a first-strike and deliver a retaliatory second-strike capable of inflicting an unacceptable level of damage, a situation of MAD is said to exist.

MX Missile: [C-11] An intercontinental ballistic missile which can be MIRVed to carry 10 warheads simultaneously. "MX" is short for missile experimental. The MX is extremely accurate to within 50-100 yards of its target. This makes it an ideal first strike war-fighting weapon.

Noninvasive Surgery: [C-6] A group of new medical technologies that employ laser beams and/or shock waves instead of a scalpel to penetrate the damaged or affected area of the patient's body. For instance, arthroscopic (needle-like device using a fiber optic light source) surgery has transformed many types of orthopedic injuries from calamities to brief inconveniences.

Nuclear Winter: [C-11] A generic term that refers to a variety of environmental consequences that may result from a full scale nuclear war. Researchers have theorized that the earth's surface will be very dark and cold due to a massive temperature inversion caused by the nuclear debris scattered in the upper atmosphere. Any life forms which do not perish as a direct result of war will die soon after in the cold snows of a long nuclear winter's night.

OPEC: [C-9] Acronym for Organization of Petroleum Exporting Countries. It is an international government organization having thirteen members who produce approximately 80 percent of the crude oil in world trade. It was formed in 1960 primarily to halt price declines being unilaterally imposed by the international oil majors.

Optoelectronics: [C-14] A field of technological research and development that has given us, among other things, fiber optics. It represents an interdisciplinary blend of electronics and optics technologies.

Parallel Processing: [C-3] A computer architecture effort in artificial intelligence which will result in the design of computers that contain many, many processors (as opposed to a single CPU) working simultaneously on small parts of one huge problem. These are called supercomputers in the United States. The Japanese use the phrase 5th generation computers to describe the use of this technology.

Pathogen: [C-2] A virus or organism that has the capacity to cause disease or death in other living organisms.

Photovoltaic Cells: [C-9] Used in conjunction with natural sunlight to convert electromagnetic radiation directly into electric current. They are often called solar cells and the devices they are found in are called solar-powered.

Pollutant Standards Index: [C-10] Developed by the Environmental Protection Agency with the Council on Environmental Quality to comply with the Clean Air Act. It is used to convert the concentration of pollutants in the air to a number between 0 and 500. These numbers equate with a series of descriptive air quality terms (good, unhealthful, smog alert, etc.).

Preferred Provider Organization (PPO): [C-6] This form of managed medical care has an advantage over the HMO in that they can be imposed on the present network of hospitals and doctors without having to build clinics or convert doctors into employees. In a PPO, a group insurance buyer agrees to steer a company's employees to particular hospitals or doctors in return for volume discounts.

Proven Reserves: [C-9] In energy terminology, this concept refers to energy resource amounts (oil, natural gas, coal) known to be available within current economic standards and extractable with current technology.

Railguns: [C-11] Military technology developed as part of the SDI efforts. Sometimes called electromagnetic launchers or guns, they use electromagnetic energy to fire projectiles at incoming vehicles at extremely high speeds. Railguns have great potential for being able to stop incoming warheads by hurling "smart bullets" at them.

Recombinant DNA: [C-2] This is presently one of the most refined genetic engineering technologies. It involves splicing specific codes along the DNA chain of a host organism in the laboratory. The engineered organism will reproduce itself with the new DNA sequence. The term clone is often used with reference to this procedure.

Response Modes: [C-12] As used here, a generic label that describes a variety of human behaviors. They are influenced by emotions, expectations, experiences, and the nature of the stimulating incident. Response modes may equate behavioral responses to changes that are usually thought to be out of one's direct personal control.

Reverse Engineering: [C-8] An astute capacity to carefully disassemble an imported device, examine it, and eventually copy it. This is a form of an unplanned transfer of technological know-how that takes place through a formal channel (i.e., export of manufactured goods).

Risk Assessment: [C-14] A relatively recent field of inquiry that sometimes carries the title risk-benefit analysis. Professionals in engineering, science, and social science are actively conducting both publicly and privately funded studies. Their projects are rigorous and replete with systematic research designs and mathematical models to determine the extent to which society is "at risk" because of certain modern technologies or their side-effects. Some of the most creative minds of our day are probably at work right now on the problem of "how safe is safe enough."

Roaming: [C-4] Cellular telephone companies have settled on "roaming" agreements which allow mobile telephone users to drive to other geographic areas and still use their phones as if they were in their home territory.

Scientific Entrepreneur: [C-2] A trend in society wherein scientists have begun to exploit the commercial advantages of their discoveries. It is quite apparent in the genetic engineering industry where the money madness often creates a competitive spirit rather than a cooperative one where new research is involved.

Skylab: [C-5] A preliminary version of a United States space station. It was a huge orbiting space laboratory launched by NASA in 1973. The project was scrapped a few years later and Skylab burned up in 1979 after its orbit had decayed.

Social Lag: [C-12] Related to the phenomenon of "social readiness" with respect to new inventions in technology. Lag refers to the length of time required for society to adapt to or accept new technological ideas, processes, or devices once they have been introduced. Sometimes called "cultural lag."

Space Adaptation Syndrome: [C-5] A malady commonly referred to as "space sickness." It continues to be a number one medical concern among space agencies internationally. It is a generic label ascribed to a series of undesirable physiological and/or psychological side effects associated with weightlessness or Z-gravity in space.

Space Recovery Vehicle: [C-5] Hollow capsules which are best described as miniature space-based factories that return back to Earth upon the completion of some experiment or productive activity. Their internal mechanisms are entirely automated. Their reentry system is activated by a signal from a ground-based control center.

Space Station: [C-5] One of NASA's flagship projects to develop a permanently manned space station. Its construction will rely heavily on the use of the space shuttle "taxi service" to transport materials and personnel into space. The completion of this proposed project will most likely be delayed as a result of the setbacks in the shuttle program in the aftermath of the Challenger accident.

Statistical Process Control (SPC): [C-7] An approach to quality assurance which differs from the traditional policy of product control via inspection. The focus of process control is on individual operations and the roles they perform in manufacturing. SPC is prevention oriented vs. inspection driven. It involves statistical analysis and increased personnel responsibility to insure all equipment and processes are operating within acceptable limits. SPC implementation focuses initially on two or three critical parameters in each process that must be controlled—operating ranges are established.

Strategic Defense Initiative (SDI): [C-11] A military strategy that was initially defined to be a 5-year research and development program to explore the possibilities of strategic defense. Decisions about its deployment will be debated in the future. ("Star War")

Superfund: [C-10] Formally labeled Comprehensive Environmental Response, Compensation, and Liability Act, this program earmarks federal funds to clean up the nation's more critical hazardous waste sites.

Technological Literacy: [C-12] A recent topic of discussion in social studies and technology education. Although numerous definitions have been proposed, technological literacy is generally thought to involve an effective level of knowledge and understanding with general reference to events and issues in science and technology and an above average grasp of technical terminology in one's field of specialization.

Technology Accordance: [C-12] As used here, this social behavior or attitude refers to the extent to which a social group is able to recognize and take advantage of the potential benefits of a technological breakthrough and simultaneously control any of its negative side-effects and/or risks.

Technology Assessment: [C-14] A label ascribed to the process of making projections about the future state of specific technologies in order that their social impacts can be assessed and planned for. An outgrowth of federal legislation which created the congressional Office of Technology Assessment in 1972.

Technology Trap: [C-12] A contemporary social phenomenon that describes our dependence on a technological system or device that we either do not understand or can not control.

Technophobia: [C-12] A general fear of technology, science, or the changes associated with these disciplines. Related somewhat to the anxiety caused by social pressures to accept and make use of new technology.

Technostress: [C-12] A modern affliction that refers to a person's inability to adapt to or cope with new computer technologies in a healthy manner. It manifests itself in two distinct but related ways: in the struggle to accept computer technology, and, in the more specialized form of overidentification with computer technology.[1] Persons who suffer from the latter adaptation problem are sometimes called hackers.

Teleconferencing: [C-4] The end result of a convergence of numerous communications technologies where some form of interactive group communication takes place through an electronic medium. Teleconferences are synchronous or "real time"—all participants are present and in touch at the same time. Teleconferences are a substitute for face to face meetings.

Tidal Power: [C-9] An alternative, renewable energy source. Involves an electric power plant using the incoming and outgoing kinetic energy of tides to drive water turbines which drive electric generators.

[1] Brod, Craig. *Technostress: The human cost of the computer revolution.* Reading, Massachusetts: Addison-Wesley Publishing Company, 1984, p. 16.

Transfer Channels: [C-8] With reference to the international technology transfer network, channels identify the formal or informal route through which the item is delivered from the supplier to the end recipient.

Turnkey Plants: [C-8] A formal channel for the transfer of technology from one nation to another. A contractual sales agreement is established whereby the technology supplier constructs a fully operational production plant for the recipient nation. Figuratively, when the facility is finished, the recipient need only "turn a key" to initiate production.

Universalism: [C-12] A characteristic of modern technology that makes it very difficult, if not impossible, for persons to live in cultures that are not at all interested in advanced technology. It describes a high level of interdependence among nations and the fact that technological changes, advancements, and accidents do not occur in a vacuum. The world is an open system that is heavily reliant on an international network of technology transfer.

Videotex: [C-4] A term used to describe computerized information systems primarily aimed at the mass market. They commonly use the telephone lines to connect a homeowner's television set to a computer database. Videotex systems commonly make use of color and graphics, and also provide menu selection as the form of easy interaction with them.

Yellow Cake: [C-9] After uranium is mined it is converted to U_3O_8, which is called yellow cake, through a sophisticated milling process. Yellow cake contains less than one percent of the U-235 isotope which is directly fissionable. Over 99 percent of the mix is the U-238 isotope. Yellow cake is further enriched before the radioactive fuel rods can be assembled.

Zipping & Zapping: [C-13] Modern day television watching habits coupled with the advent of remote control devices have created a heightened level of impatience among viewers. Zapping denotes the practice of switching channels up and down the selection dial to avoid watching commercials or to simply get a sampling of several different programs simultaneously. Zipping requires that the individual also have a remote controlled video cassette recorder (VCR). This technique enables the viewer to "zip" through a prerecorded tape to avoid watching any segments he/she is not interested in (commercials, time-outs during sporting events, etc.).

As mentioned at the beginning of this chapter, the list of technology terms you have just reviewed is by no means exhaustive. Between the time of this writing and your reading of the material, any number of new terms will have surfaced in all technology-related disciplines. As you read through this textbook, please make an effort to expand your own technology vocabulary—endeavor to learn new words and avoid simply "glossing over" key terms in your reading. You may refer back to this introductory chapter as necessary to review these definitions when the concepts are discussed in more detail later.

We hope that this method of introducing the textbook will be helpful as you learn about contemporary topics and issues in technology.

SUGGESTED READINGS FOR FURTHER STUDY—CHAPTER 1

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Chapter 2

DEVELOPMENTS IN GENETIC ENGINEERING

DATELINE

Washington, D.C.

Following years of developmental research, the nation's biotechnology companies are moving a new generation of custom-designed grains, vegetables, fruits and ornamental shrubs to the market. Plant breeding has traditionally been a long, tedious and highly uncertain process. Breeders started out with seeds and laboriously crossed existing crop plants with their wild relatives. They next waited patiently in the hope that commercially important traits such as disease resistance or a shorter growing season would be incorporated into the new plants. This procedure often took five years or longer.

The new plant transformation technology replaces the seeds with genes and cells as the starting point for yielding new varieties. For example, in Cinnaminson, New Jersey, the DNA Plant Technologies Corporation has entered into a joint venture with Kraft Foods. They are developing a new line of ''crisper,'' ''tastier'' vegetables that will be grown from single cells instead of seeds — the proposed product name is ''Vegisnax.'' It certainly appears that the ''designer gene'' concept has acquired a new interpretation . . . .

INTRODUCTION

Biotechnology is a term that has been used in the scientific community for years, but it has assumed a revised definition during the short lifespan of the genetic engineering industry. Biotechnology emerged onto the center stage of contemporary society with great speed and "gusto." Most of the advances in genetic engineering transpired after the decade of the 1980s was well underway. The actual "birth" of the genetic engineering industry is generally marked in the mid-1970s. Throughout its evolution, an assortment of descriptive statements have appeared in the media regarding recombinant DNA, gene splicing, genetic manipulation, cell fusion, and so forth. Biotechnology has become accepted as the "umbrella" term which encompasses all of these techniques. The Congressional Office of Technology Assessment provides the following explanation:

Biotechnology, broadly defined, includes any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants or animals, or to develop micro-organisms for specific uses.[1]

Genetic engineering has triggered a great deal of public scrutiny and interest over the years. Consequently, it represents many things to a variety of professional disciplines. Molecular biologists view it as a powerful scientific tool while entrepreneurs and venture capitalists recognize its versatility as a novel technology. For agronomists (specialists in field-crop production and soil management) and medical scientists, genetic engineering holds the promise for increasing food production and curing dreadful genetic diseases. And of course there are numerous critics who focus on the potential for its abuse in the environment, among people, and in the defense sector.

It appears that genetic engineering heralds abundance for humanity but simultaneously spells a series of mysterious potential risks. Genetic engineering spent most of its youth "behind closed doors" in research laboratories. It has since entered adolescence and the "real world" beyond those walls. In doing so, it has become a subject of technological controversy. Genetically engineered microorganisms in any application present an array of complex problems for both the environmental ecosystem and for the regulatory agencies that are commissioned to protect it.

The commercialization of biotechnology started in the mid-1970s when a number of small entrepreneurial firms were founded in the United States. These companies were specifically formed to expand the ever-growing body of fundamental knowledge in molecular biology and to exploit it toward a profitable end. The market for genetically engineered products has grown exponentially and will continue to do so well into the next century. Large, well- established corporations in the United States, Japan, and Europe have expanded their research and development programs to investigate new techniques akin to genetic technology. It appears that a struggle is being waged to dominate a fledgling new market whose lifeblood is found in basic scientific research.

It is highly probable that no other technology has been born under such intense public scrutiny. This chapter describes a variety of applied genetic engineering feats. The broad spectrum of disciplines involved in genetic research is presented with an eye for both the promise and the perils associated with the fruits of their labor. The following questions will be addressed.

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[1] *Commercial Biotechnology: An International Analysis.* Office of Technology Assessment, Washington, D.C. New York: Pergamon Press, 1984.

1. What is the economic outlook for biotechnology in the United States? Will the United States be able to retain its technological edge in this field?
2. Why has the question of regulation in the genetic engineering industry been so complicated to address?
3. What types of commercial breakthroughs are projected to be made in the health care field and gene therapy?
4. Will genetic engineering endeavors in agriculture lead to another "Green Revolution?"
5. How can the scientific knowledge associated with genetic manipulation be used most effectively in industry?
6. Is there a connection between biotechnology research and the defense profile of the United States?

KEY CONCEPTS

As you review the material presented in this chapter, you should be able to explain what is meant by each of the following terms and phrases:

Scientific Entrepreneur
Recombinant DNA
Cell Fusion
Bioprocessing Technology
Intergeneric Organism
"Environmental Release"
Gene Therapy
Monoclonal Antibodies
E. Coli
Biological Containment
Pathogen
Agrigenetics

THE CRITICAL TECHNOLOGIES

The United States university system boasts a well-established life science base. This, coupled with an entrepreneurial spirit and the availability of financing for risky ventures, has led the country to the forefront in the commercialization of biotechnology. Generally speaking, the laws and policies of our government have enabled industrialists and scientists to capitalize rapidly on genetic research findings. A major portion of this basic research in biotechnology to date has been conducted within the university system and government laboratories. Significant contributions have also been made by the smaller biotechnology firms. Additionally, the United States industrial sector has exemplified its diversity and flexibility with reference to making efficient use of numerous laboratory achievements in genetic research. These characteristics have facilitated the rapid commercialization of biotechnology.

RECOMBINANT DNA TECHNOLOGY

Recombinant DNA (rDNA) is presently the most refined genetic manipulation technique. It consists of splicing specific codes along the DNA chain in order to form a stable combination of information that will produce a specific result. The experiment is considered successful to the extent that desired traits are passed on to succeeding generations. Recombinant DNA technology can be used in a wide range of industrial enterprises to develop:

☐ Microorganisms that produce new products.
☐ More efficient methods of producing currently available products.
☐ Large quantities of products that are scarce in the natural environment.

This technique can also be used to develop "useful" micro-organisms that have the work-horse ability to degrade toxic wastes. New strains of agriculturally essential plants such as wheat, corn, and rice represent another by-product of rDNA technology.

Science Principles

A cursory review of the structure and function of the **DNA** (deoxyribonucleic acid) molecule as the building block of all life forms provides the basis for understanding rDNA technology. You may recall from previous biology courses that the nucleus of each living cell hosts a number of chromosomes. Different species have different numbers of chromosomes: humans have 46, corn has 20, goldfish have 94, etc. Strung along the chromosomes are the units of the genetic code, the genes which are composed of DNA. If all the DNA in a single human cell were uncoiled, it would stretch out about three meters. In these three meters of human DNA there are some 5,000,000 genes, of which at least 100,000 define the human form. In each DNA molecule there is the blueprint (genetic code) for bones, muscle, tissue, blood, etc. Every living being has its own unique genetic make-up. The DNA present in every cell of every living organism has the capacity to direct the functions of that cell.

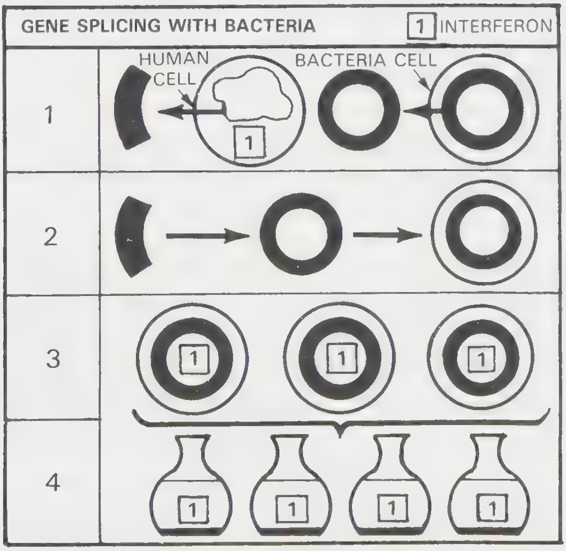
Directly altering an organism by changing its genetic code requires that the specific gene (or set of instructions) along the DNA coil be modified and that this same set of instructions be changed in *every* cell of the organism. This task is not too difficult to accomplish in the contemporary research laboratory with single-cell organisms such as bacteria. But remember that the human organism is 100 trillion times as complicated in terms of cell structure!

It is for the reason of complexity that the most obvious candidate for the pioneer research in genetic engineering was a single-cell bacteria. The organism selected by scientists in the early-1970s was a bacterium commonly found in the human intestinal tract: Escherichia coli (E. coli). Besides chromosomes, the E. coli nucleus contains plasmids which are small strands of DNA. A plasmid exists and reproduces as a circular molecule. The benchmark genetic manipulation research conducted by Herbert Boyer (University of California San Francisco), Stanley Cohen (Stanford University), and their colleagues provided the information needed to "engineer" E. coli.

The biologic principle underlying recombinant DNA technology is simple but staggering. If genes from a higher organism are implanted in bacteria, the bacteria will follow the genetic instructions of the higher cell. An E. coli bacterium's cells divide and reproduce every 25-40 minutes. They continue to do this even after the genes from another organism have been spliced into them.

To provide an example of rDNA technology, the diagram in Figure 2.1 illustrates the procedures used by a genetic engineer to clone the human protein, interferon. Human cells that are invaded by viruses naturally produce small quantities of interferon. This protein is effective in fighting many viral diseases including some forms of cancer. The gene for interferon production is mapped using sophisticated laboratory equipment and removed from a human chromosome. It is next inserted into the E. coli bacterium which acquires the capacity to make interferon.

If the genetic engineer's objectives are fulfilled, a new organism has been created. The transformed bacterium possesses a mixed, or recombinant plasmid wherein human and bacterial genes are present side by side. The bacterium is cultured under carefully controlled conditions in order to allow the gene for producing human interferon to work in its new site with the E. coli. Once the bacterium has been correctly transformed, interferon synthesis can commence using huge vats or fermentation chambers. The rapid reproduction cycle of the bacterium speeds this process. Finally, substantial quantities of interferon are extracted for use primarily in the health care field.



Using recombinant DNA to make interferon. (1) An enzyme snips DNA for interferon from chromosome of human cell. A plasmid (a circular piece of DNA) is chemically extracted from a bacterial cell. (2) An enzyme opens plasmid ring. When human DNA and plasmids are mixed, they fuse. Hybrid DNA with both human and bacterial material is implanted in new bacterial cell. (3) Unique bacteria now capable of manufacturing human interferon, reproduce manyfold. (4) Interferon is produced by bacteria in quantity and extracted for medical use.

Figure 2.1 The recombinant DNA procedure using E. coli to engineer the human protein interferon.

Human interferon is so potent that the body produces it in minuscule amounts. For this reason, its use in the medical field was extremely limited until recently (it used to cost $70 to $100 per millionth of a gram!). During the late 1970s, a Finnish laboratory supervised by Dr. Kari Cantell processed 90,000 pints of blood and produced only one tenth of a gram of pure interferon. Subsequently, to attack a common cold, doctors treating one patient in a clinical study needed to use about $2000 worth of interferon. Using rDNA, these newly engineered bacteria produce interferon as a metabolic by-product and the same amount is acquired in the laboratory for about a nickel. Similar accomplishments have occurred in the rDNA synthesis of human insulin and the human growth hormone.

MONOCLONAL ANTIBODY TECHNOLOGY

Protoplast fusion is another genetic engineering technology that has received much critical acclaim in recent years. In this procedure, the external walls of two different types of cells are removed allowing their specific genetic materials to combine and mix. This fusion causes a natural (but random) genetic recombination. The modified cell line resulting from such a fusion, also known as a **hybridoma**, produces large quantities of **monoclonal antibodies (MAbs)**. The term monoclonal indicates that they are produced by the offspring, or clones, of a single hybridoma cell.

Monoclonal antibodies have the potential to be used for many purposes including the diagnosis and treatment of disease and the purification of proteins. (Another less extreme example of the use of MAbs is that of discriminating different kinds of meat in a sample of mince. Researchers have successfully used antibodies to identify horse or kangaroo meat that was being passed off as minced beef.) MAb technology has also been suggested for use in developing new contraceptives through the production of antibodies to the proteins found in human sperm. It is even possible that these antibodies could be sex-specific (for example, acting only on sperm carrying X chromosomes female or Y chromosomes male). One can only imagine what the use of this technology would do for the practice of gender predetermination among child-bearing couples!

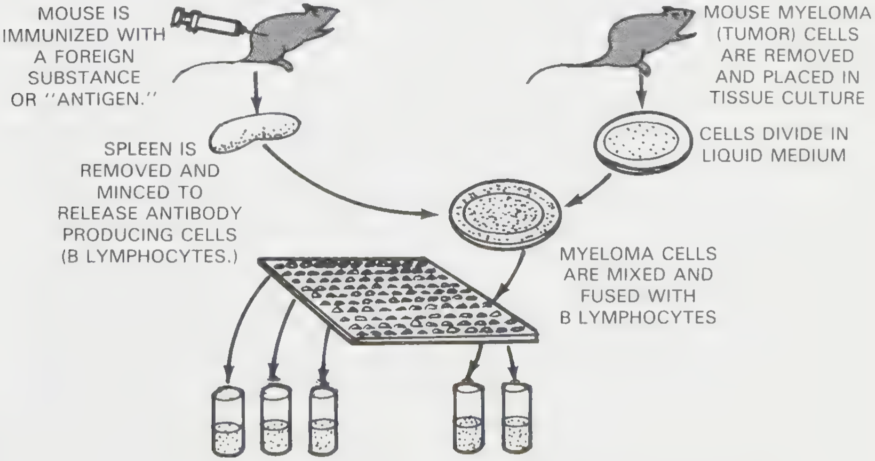
Science Principles

The production of antibodies in higher life forms is one aspect of a complex series of metabolic processes referred to as the **immune response system**. This system is located in the spleen, lymph nodes, and blood of the organism. Specialized sets of cells known as B lymphocytes are organized to detect and destroy foreign substances that pose any sort of threat (e.g., bacteria, viruses, pollen molecules, etc.). As these foreign substances, called **antigens**, enter the body, the special cells churn out large numbers of complex molecules called **antibodies**. The structure of these molecules enable them to lock on to particular antigens. More importantly, specific antibodies will only fit one kind of antigen. The foreign substances are thus blocked in their action. The end result of this aspect of the immune response is the antigen's removal from the body.

Separate from their natural functions in the protection of life forms via this immune response, antibodies have long been used in clinical research to identify particular molecules or cells. They also play a major role in the diagnosis of diseases. Antibodies that recognize known antigens are commonly used to detect the presence and level of drugs, hormones, bacterial elements and viral products in sensitive blood samples.

Antibodies are actually large proteins which are specified genetically. Molecular biologists have devoted a great deal of research toward considering how the genes in antibody-producing cells are switched on and off to produce the correct molecule at the right moment. It is this type of inquiry which led to the development of the monoclonal antibody technique in genetic engineering.

One method that is used widely to prepare MAbs is shown in Figure 2.2. The purified antigen being studied is injected into a mouse. A few weeks later, the spleen of the mouse is removed. The antibody-producing cells are isolated from the spleen and fused with myeloma (tumorous) cells. Antibody-producing cells cannot survive on their own in artificial cultures, they must be fused with another type of cell and cultured in a medium that will only support the growth of the hybridoma.


MOUSE IS IMMUNIZED WITH A FOREIGN SUBSTANCE OR "ANTIGEN."
MOUSE MYELOMA (TUMOR) CELLS ARE REMOVED AND PLACED IN TISSUE CULTURE
SPLEEN IS REMOVED AND MINCED TO RELEASE ANTIBODY PRODUCING CELLS (B LYMPHOCYTES.)
CELLS DIVIDE IN LIQUID MEDIUM
MYELOMA CELLS ARE MIXED AND FUSED WITH B LYMPHOCYTES

The products of this fusion are grown in a selective medium. Only those fusion products which are both "immortal" and contain genes from the antibody producing cells survive. These are called 'hybridomas." Hybridomas are cloned and the resulting cells are screened for antibody production. Those few cells that produce the antibodies being sought are grown in large quantities for production of monoclonal antibodies.

Figure 2.2 One technique used to prepare monoclonal antibodies (cell fusion). (Office of Technology Assessment)

The hybridomas that result from this procedure are cloned and each clone is tested for the production of the antibody desired. These clones may be established either in an *in vitro* (outside a living body or in an artificial environment) culture system or may be injected into mice where the hybridomas grow in abdominal cavity fluids. Either of these methods allows for the preparation of large quantities of very specific MAbs to counteract almost any available antigen. The antibodies produced by MAb technology are homogeneous and their production is predictable. Conventional immunological methods produced polyclonal antibodies which possess differences in their affinity for the selected antigen. This fact alone illustrates the importance of this genetic engineering feat to the advancement of medical science.

BIOPROCESS TECHNOLOGY

Advances made in bioprocess technology will ultimately determine the commercial success of selected industrial applications for both rDNA and cell fusion techniques. Bioprocess technology is not exactly a genetic technique, but it allows the biological methods of production to be adapted to large-scale industrial use. **Bioprocesses** are systems wherein complete living cells or their counterparts (e.g., enzymes, chloroplasts, etc.) are used to create desired physical or chemical changes. Bioprocesses have been used for centuries to produce beer and alcoholic beverages as well as fermented foods like yogurt.

Commercially oriented industrial biological syntheses are currently executed in single batches allowing only a small quantity of product to be recovered from large quantities of cellular components, nutrients, wastes, and water. In large scale fermentation tanks, genetically engineered microbes are placed in a liquid solution of catalytic nutrients required by the microorganisms to propagate. One method used to separate the desired end product (the protein Interferon) from the fermentation solution entails running the mixture through membranes which collect the larger protein molecules and allow the smaller molecules to pass through. Another technique uses “bioreactors” where either the catalytic enzymes or the cells containing the recombinant DNA genes are immobilized on a substrate. Improvements made in techniques for immobilizing cells or enzymes, as well as the design of bioreactors, have helped to increase production and facilitate the recovery of many substances (e.g., proteins, hormones, wastes). However, more research in this area is still needed. Genetic techniques are also being developed that can assist in the design of more efficient bioreactors, sensors, and recovery systems.

Current applications of bioprocess technology include:

1. Production of cell matter such as baker’s yeast and single-cell proteins.
2. Production of cell components such as enzymes and nucleic acids.
3. Production of chemical products including ethanol, lactic acid, and antibodies.
4. Catalysis of single substrate conversions such as glucose to fructose.
5. Catalysis of multiple-substrate conversions involved in the treatment of

biological wastes.

Present research pursuits in these disciplines focus on the interrelationship between the genetic technologies described above such as rDNA and MAb, and several traditional bioprocessing techniques. Progress is being made in both solving the engineering problems that are unique to genetically modified organisms and in identifying ways in which genetically altered organisms may be used to enhance the efficiency of certain bioprocesses.

The next section reviews the economic outlook for biotechnology in the United States. It is evident that further developments in bioprocess engineering coupled with innovations in genetics will form the foundation for continued advancement, economic prosperity, and leadership within this industry.

AN ECONOMIC PROFILE OF THE BIOTECHNOLOGY INDUSTRY

By definition, scientific endeavors involve the systematic pursuit of new knowledge toward the development of theories and laws. One of the basic tenets of science traditionally has been the open exchange of new discoveries and information to stimulate further research.

THE SCIENTIFIC ENTREPRENEUR

As mentioned earlier, the entrepreneurial spirit is alive and well in the United States genetic engineering industry. It has had a significant influence on the rampant pace of development and commercialization of the science and technology of genetics research. An entrepreneur is generally driven by a profit-making instinct and the anticipation of ultimate financial rewards. The commercialization of the genetic engineering industry has introduced a new breed of individuals along the way—the scientist-entrepreneur. The title itself is paradoxical!

There may actually be a trend developing among scientists who are attempting to exploit the commercial advantages of their discoveries. However, the money madness evident during the early days of the gene splicing industry was a lot more obvious to the point of seeming excessive at times. Venture capital from companies like Standard Oil, Kraft Foods, National Distillers & Chemical Company, and Eastman Kodak enabled a number of small genetic engineering laboratories to get off the ground and remain solvent for significant periods of time.

Some concern has been expressed by academicians regarding the commercial "hoopla" connected with some DNA research. The entrepreneurial spirit may actually be perceived as a threat to scientific inquiry in as much as it has a tendency to squelch the free flow of ideas at scientific meetings. Smaller companies, desirous of a piece of the action, may be tempted to conduct "shotgun" experiments devoid of the necessary quality control checks expected. The days of the conventional method of announcing a scientific breakthrough via a publication in a prestigious journal appear to be behind us—at least for the time being in the genetic engineering industry.

LEADING BIOTECHNOLOGY COMPANIES

The firms that have demonstrated a commitment to exploiting the commercial aspects of biotechnology in the United States can be roughly categorized into two groups: new biotechnology firms (NBFs) and established companies/corporations. NBFs are typically described as entrepreneurial ventures that were specifically formed to commercialize innovations in biotechnology. One could count the number of NBFs in existence in the United States during the early 1970s on two hands. In less than a decade, this number has easily surpassed 100 firms.

Most of the currently established biotechnology firms were founded after 1976 which is the year Genentech was born in the San Francisco Bay area. Some economists consider this company to be the biotechnology industry's first superstar due to its overwhelming success on Wall Street. Most NBFs have an organizational structure that directs applied biotechnical research toward commercial product development. In other words, they operate on a strong research base that tends to be specialized in given techniques or emphases such as monoclonal antibodies for diagnostic kits. The larger established corporations that have taken an interest in biotechnology seem to be more process oriented. Many of these larger firms have invested in in-house R&D programs to determine where biotechnology can be most effectively applied to new products and processes. These multi-product companies compete in several more traditional industrial sectors including pharmaceuticals, energy, chemicals, and food processing.

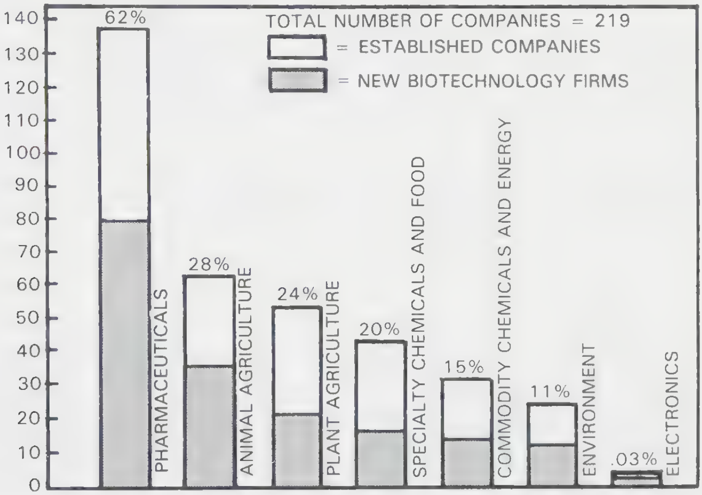
A large percentage of the biotechnology firms in the United States seems to be specializing in the development of products germane to the pharmaceutical industry. A second important arena for dedicated commercialization is found in the agricultural discipline including both horticulture and animal husbandry. Relatively fewer United States firms are pursuing commercial applications of biotechnology in the areas of food additives, specialty chemicals, energy, the environment, and electronics. Refer to Figure 2.3.

If one were to speculate on this particular distribution of industrial involvement, it might be safe to conclude:

1. Pharmaceutical companies have had years of experience with biological production methods which has enabled them to take advantage of the new technologies
2. Pharmaceuticals are profitable products since they tend to offer higher rates of return on sales and stockholder equity alike.
3. Conventional technologies are still working quite well in the energy field and corporate investments in existing capital equipment is intensive.
4. There is still a great deal of uncertainty surrounding the potential use of biotechnology procedures with reference to environmental applications.

This list of possible explanations is certainly not exhaustive, but it may provide some insight into the current profile of biotechnological enterprises in the United States.

Genentech, Inc., more than any other company, seems to symbolize the commercial potential of biotechnology, Figure 2.4. The company was founded just over a decade ago by a young venture capitalist who convinced Herbert Boyer (the biochemist who developed the gene splicing technique in the early 1970s) to help him start a company to focus on the use of recombinant DNA



*The total percentage of firms exceeds 100 percent because some companies are applying biotechnology in more than one industrial sector

Figure 2.3 Percentage of firms in the United States pursuing applications of biotechnology in specific industrial sectors. (Office of Technology Assessment)

Genentech Inc

Figure 2.4 Genentech, Inc. is a leading manufacturer of genetically engineered pharmaceutical products. (Michael Dafferner)

technology to develop marketable products. Genentech's researchers are persistent and seem to be intent on revolutionizing the pharmaceutical industry through the recombinant production of valuable natural proteins. Among its steady stream of research breakthroughs, Genentech: (1) Cloned human insulin in 1978 in the laboratory; (2) Licensed this human insulin to Eli Lilly & Company in 1982 making it the first rDNA drug to reach the market; (3) Cloned the human growth hormone in 1979; (4) Received FDA approval for the human growth hormone in 1985 and marketed the product itself under the name Protopin; and (5) Successfully cloned gamma interferon in 1981 as a promising tumor-fighting substance that is being clinically tested. Continued success may soon turn this research and development "boutique" into a major pharmaceutical company.

Several other biotechnology firms have also made significant contributions to the human therapeutics market including: Cetus, Biogen, Hybritech, and Genetic Systems. Hybritech and Genetic Systems are both quite visible in the contemporary spectrum of genetic engineering companies. These two firms are currently producing *in-vitro* diagnostic tests based on hybridoma technology. Hybritech is based in San Diego and was acquired by Eli Lilly & Company. Genetic Systems, located in Seattle, agreed to be purchased by Bristol-Myers. These acquisitions and others like them are changing the economic profile of this industry. Some economic observers believe that the biotechnology industry has secured a new identity characterized by industrial credibility and corporate approval.

Monsanto is an example of an established chemical company that has made a definitive commitment to biotechnology. The company invests heavily in research and maintains a broad focus which encompasses human health, animal nutrition, and plant agricultural products. In building up its human health product arm, Monsanto purchased G.D. Searle in the mid-1980s. The bulk of Monsanto's plant research (such as modified plant cells resistant to herbicides) is being conducted in-house in its multi-million dollar life sciences research center just outside St. Louis. This facility houses an impressive series of growth chambers whose "microclimes" simulate conditions from the deserts of Saudi Arabia to the rain forests of Brazil. See Figure 2.5.

American Cyanamid is pursuing biotechnology programs in both the human health and agricultural areas. One of its chief products in human health is a collaborative research effort with Molecular Genetics to develop a vaccine for herpes. It has also entered an R&D venture with Cytogen to develop immunocytotoxic agents for cancer therapy. This technique is based on the attachment of a chemotherapeutant to a monoclonal antibody which homes in on the cancer cells to destroy them with minimal harm to the adjacent healthy cells.

These examples of industrial endeavors to commercialize biotechnology are provided to illustrate the dynamic nature of this industry. The increasing involvement of the larger, established corporations may lead to a confrontation of their interests with those of the small biotechnology companies. In some cases, the pioneering companies have become more powerful since the early 1980s. At that time, the best deal they could create with a large corporation was a licensing agreement under which they received R&D funding but gave up their proprietary stake in the product. Typical royalty agreements for these small research firms were less than 10 percent.

With continued advancements in technology, biotechnology products are closer to the point of realization and the nature of business arrangements has improved. Licensing deals feature much higher royalty percentages and joint ventures have become more and more common. Some analysts believe that the number of small biotechnology firms will stabilize and maintain their strength due to these developments. Others believe that only a few stand-alone companies will emerge from the current numbers of start-up biotechnology companies; others will become technology acquisitions and the rest will slowly die out. In any case, the United States foothold in the international biotechnology industry is eminent.

Figure 2.5 High technology is at work throughout Monsanto Company's Life Sciences Research Center. Two Monsanto researchers are shown here examining wheat grown in one of the 123 plant growth chambers in which almost any climate and soil condition in the world can be duplicated. Researchers can program growing conditions ranging from tropical rain forest to barren desert by feeding information into computer terminals. (Monsanto Company, St. Louis, MO)

THE TECHNOLOGICAL EDGE IN GENETIC ENGINEERING

The United States efforts to commercialize biotechnology are stronger than those of many other nations worldwide. The strength of these efforts is derived in part from the unique combination of competition and complementarity that exists between NBFs and established United States companies. The extent to which this symbiotic relationship will continue to enable the United States to maintain its international technological lead in basic research remains tentative.

There are several public policy issues that persistently influence the status of the biotechnology industry. Primary issues are funding, regulation, and trade policy. The strategies employed to resolve these issues will be most significant in determining whether U.S. biotechnology firms will either end up leading the world and dominating markets with accompanying employment and economic benefits or follow the course of the semiconductor industry with technological breakthroughs being made in the United States and the competitive edge winding up on foreign soils.

Japan is often viewed as the leading competitor of the United States in biotechnology developments. Japanese companies have extensive experience in bioprocess technology and the government has targeted biotechnology as the key technology for this century's duration. Biotechnology industrialists have discovered that it is one thing to engineer a product in the laboratory and quite another to scale up to a 50,000-liter fermentation tank. For this reason, it is essential for the United States to direct more research efforts toward problems associated with bioprocessing for production.

Genetic engineering in Europe has been relatively devoid of the hype and stock market frenzy that has accompanied its evolution in the United States. Large, established pharmaceutical and chemical companies have been hesitant to invest significantly into biotechnology. Additionally, their tax laws are not favorable toward venture capital formations and risk-taking enterprises. Nevertheless, West Germany, the United Kingdom, Switzerland, and France have all made credible inroads into this technological arena. One should not underestimate the competitive strength of European multinationals such as Hoechst of West Germany; Rhone Poulenc and Elf Acquitaine of France; ICI, Glaxo, and Wellcome of the United Kingdom; and Hoffman-La Roche of Switzerland.

In order to maintain its technological edge in bioengineering, if that is indeed a public expectation, the United States government must refrain from cutting off funding for basic life science research as well as generic applied research. Other areas where strategic modifications and/or extreme changes must be made include: trade policy regarding biotechnology transfer, intellectual property laws, health and safety legislation, and environmental regulation. It is not within the scope of this chapter to explore each of these areas, in detail. The suggested readings at the end of this chapter will provide additional information. The following segment will provide an overview of the issue of regulation in the biotechnology industry.

REGULATORY CONSIDERATIONS

Many industrialists and business leaders grimace at the mention of regulation or regulatory agencies. These discussion topics often bring to mind endless government bureaucracy, production halts and increased company expenditures directed toward legal compliance. This does not seem to be the case however among the nation's biotechnology firms. For several years, laboratory scientists and entrepreneurs alike have been waiting in anticipation for clear-cut regulatory guidelines to be issued by the federal government.

The absence of a coherent regulatory policy since the initial breakthroughs were made in genetic engineering has caused a series of suspended or delayed research projects. Several companies have been reluctant to seek approval for their products. Critics of the gene splicing industry have successfully exploited the government regulators' lack of coordination. They have received a lot of press in the bargain and have argued repeatedly that certain government agencies have been remiss in their review of the proposed product's safety and/or its potential environmental impact. It has become evident that the continued efforts toward the commercialization of biotechnology will be greatly influenced by the letter of the laws established to regulate this industry — too little regulation vs. overregulation. Which of these situations is worse?

ATTEMPTS TO REGULATE THE BIOTECH INDUSTRY

You may recall that the function of a government regulator in the United States is to implement and enforce the wills of Congress. Regulating agencies do not create laws on their own. Although they may be required to interpret the legal terminology in some instances, it is their responsibility to follow the statutes provided in Congressional Acts.

A number of federal regulatory agencies have battled for control of biotechnology for more than a decade. These federal agencies include: (1) National Institutes of Health's (NIH) Recombinant DNA Advisory Committee (RAC); (2) Environmental Protection Agency (EPA); (3) Food and Drug Administration (FDA); (4) Department of Agriculture (USDA); and (5) Occupational Safety and Health Administration (OSHA). From time to time, representatives from each of these agencies has stepped forward to provide insight and recommendations with reference to research being conducted or proposed in the field of genetics. Several pieces of legislation from which these individuals have derived their statutory authorization are summarized in Figure 2.6. Regardless, the discourse concerning "who regulates?" still remained inconclusive.

With so many unknowns in this technical field, Congress has been puzzled as to whether or not existing laws are adequate. If they are deemed appropriate, how will new product proposals fit into the current network of agencies, jurisdictions, and authorities? Do the government agencies being considered have sufficient technical expertise to critically evaluate the proposals being submitted for field testing or marketing of genetically engineered products?

U.S. LAWS UNDER WHICH BIOTECH R&D CAN BE REGULATED

Agency	Legal authority	Possible coverage
National Institutes of Health	NIH recombinant DNA guidelines	All federally funded recombinant DNA research
Food & Drug Administration	Food, Drug & Cosmetic Act	Organisms used as food, food additives, drugs, animal drugs
	Medical Device Amendments of 1976	Organisms used as therapeutic implants
Environmental Protection Agency	Federal insecticide, Fungicide & Rodenticide Act	Organisms used to control any pests
	Toxic Substances Control Act	Organisms used in production of or as commercial products not covered by other laws
Department of Agriculture	Plant Quarantine Act	Protection from importation of injurious plant diseases and pests
	Plant Variety Protection Act	Regulates widespread growth of novel varieties of plants
	Noxious Weed Act	Prohibits use of any plant that has adverse environmental impact
	Virus, Serum & Toxin Act	Animal biologicals in interstate commerce
All executive agencies	1977 Executive Order on Exotic Organisms	Restricts release of unnaturally occuring organisms because of potential environmental harm

Figure 2.6 U.S. laws under which biotech R&D can be regulated.

The process of sifting through the literature and government documents concerning regulation in the biotechnology industry can be frustrating. A sense of confusion pervades many of the issues which sometimes appear straightforward on the surface. Some of the mind-bending inquiries that political leaders have confronted over the past few years include:

1. What constitutes a “new” organism or substance?
2. If a plant is used as a pesticide, does it fall under the jurisdiction of the USDA or the EPA?
3. How much alteration of an organism is needed to make it a “new” substance and therefore subject to regulation?
4. Since microbes are living products, do they fall into some sort of special regulatory category?

5. How should one define the concept of environmental release? When does an engineered organism cease to be contained?
6. Are the engineered bacteria pathological? How can this be determined in an ethical manner?

The disturbingly rhetorical nature of these types of questions should serve to shed some light on the inconsistent profile of regulatory standards in this industry.

RECOMBINANT DNA ADVISORY COMMITTEE (RAC)

One of the first steps taken toward the implementation of guidelines for genetic engineering research occurred in the mid-1970s. It was at an international conference sponsored by the NIH (National Institute of Health) and the National Academy of Science held at Asilomar, California, that the topic of biological containment was first discussed. The use of physical containment barriers to insure safety is a by-product of modern science and technology. **Biological containment,** specific to the gene-splicing industry, involves: (1) using bacterial hosts that are too weak to survive outside the laboratory and (2) using micro-organic vehicles that can only grow in specific hosts whose behavior is predictable. The Recombinant DNA Advisory Committee (RAC) was organized several months after this conference at the behest of the scientific community itself. This body was initiated to fill a vacuum that existed for the federal review of scientific experiments until the actual regulating agencies could get their own rules in place.

For nearly a decade, most federal government oversight of genetic engineering was completed by this committee. The NIH guidelines specified that the RAC was responsible for the review of any proposals from scientists who were receiving federal funds for their research involving the following:

1. Human genetic engineering.
2. Release of genetically altered organisms into the environment.
3. Deliberate genetic transfer of antibiotic-resistant traits.
4. Cloning of genes to produce toxins that are potent to vertebrates.

As the field of genetic engineering developed and expanded, researchers became increasingly interested in introducing their products to the world beyond the laboratory walls. For many years, private industrial firms were exempt from the RAC's jurisdiction since they were not receiving federal funding. Still, many companies elected to participate in the review process on their own. As a result, the RAC was called upon to deal with requests from commercial firms in addition to the university scientific community.

It appeared that the RAC was gradually being pushed away from its original, purely research-oriented role. Some members of the review panel expressed discomfort with the manner in which individual industrial proposals had to be handled. The proprietary nature of their requests often demanded secrecy and the RAC was accustomed to dealing openly among academic scientists. Despite their dilemma, the RAC continued in its somewhat controversial capacity for fear that it may be the only legislative checkpoint that would provide guidance to these companies.

It was only a matter of time before the legality of the RAC's review procedures was challenged in court and in the press. Subsequently, the federal government was pressured to reassess its entire biotechnology regulatory program. Much of the investigative and analytical work toward this reassessment took place in the mid-1980s. The outcome was a comprehensive package of rules, guidelines, and technical definitions designed to formally set the nation's policy for regulating the ever-changing biotechnology industry.

COORDINATED FRAMEWORK FOR REGULATION OF BIOTECHNOLOGY

After several years of study, the federal government finally released its plans for regulating the products of biotechnology/engineering. The legislative framework was issued through the Executive Office of the President by the Office of Science and Technology Policy.[2] For biotechnology products, the responsible regulatory agencies were identified as the Environmental Protection Agency (EPA), Department of Agriculture's Animal & Plant Health Inspection Service, Occupational Safety & Health Administration (OSHA), and Food & Drug Administration (FDA). Research guidelines will be set and monitored by the National Institutes of Health (NIH) and the National Science Foundation (NSF). A newly established interagency Biotechnology Science Coordinating Committee (BSCC) was assembled to provide ongoing coordination and consistency of the scientific policies and scientific reviews prepared by these units.

The primary intent of these administrative guidelines is to achieve a balance between regulation and growth. The regulation must be adequate to ensure health and environmental safety, but flexible enough to avoid impeding the growth of this important industry. In other words, it is expected that the guidelines will be able to change over time as the science and technology of genetic engineering evolve. It will ultimately be the role of the interagency BSCC to monitor these developments and make recommendations for new laws and regulations.

Under the present guidelines, the FDA will oversee human health care products and animal drugs. The EPA will regulate genetically engineered microbes. The USDA will be responsible for the regulation of gene-altered animal vaccines and plants as well as having the jurisdiction to work with the EPA on microbes that could affect crop plants. OSHA has been appointed to review the use of genetically altered agents in the work place and to insure the effectiveness of biological safety and health programs practiced in-plant.

Due to the array of agencies who have been assigned to be involved in regulatory endeavors in biotechnology, the BSCC found it essential to develop specific definitions to insure a coordinated scientific approach to the legal process. Two of the critical areas of concern involved: (1) identifying which organisms should be considered for certain types of review and (2) defining what constitutes "release into the environment." A brief description of concerns of this committee's recommendations follows.

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[2] *Coordinated Framework for Regulation of Biotechnology.* Office of Science and Technology Policy. *Federal Register,* June 26, 1986, *51* (123), 23301-23350.

INTERGENERIC ORGANISM. These "new" intergeneric organisms are formed by the deliberate combination of genetic material from sources in different species. This standard is based on the taxonomic designations of microorganisms. Taxonomy is a common language used by scientists to describe how organisms are similar and dissimilar.

PATHOGEN. This term describes micro-organisms that belong to a pathenogenic species or that contain genetic material from source organisms that are pathenogenic. A **pathogen** is a virus or organism that has the ability to cause disease in other living organisms. A disease is an abnormal physiological function in an organism due to the presence of a foreign substance that has caused some sort of infection.

ENVIRONMENTAL RELEASE. This particular concept has been the subject of much debate and controversy in the scientific community as well as among the general public. The idea of "containment" has traditionally been used to describe physical conditions which acutely limit the release of a substance, for example, a contained laboratory fermentation facility. As you recall from a previous section, containment can also be "biologic" due to the ability of an organism to live, grow, multiply, and move on its own. The topic of physical containment may imply laboratory conditions or the use of greenhouses. Some effective barriers used successfully in agriculture include: microplots for soil bacteria and fungi; fenced areas for noninfective animals; and removing or covering the reproductive parts of plants and animals.

Development of a concrete definition for "environmental release" will probably occur in the near future. In the interim, the EPA's approach will be to determine whether or not a microorganism is contained rather that released. Generally speaking, a contained greenhouse, fermenter or other device is a building or structure that has a roof and walls. See Figure 2.7. It should also have a ventilation system to minimize the accidental release of microbes to the outdoors. A system for sterilizing wastes and water runoff, and a system for restricting insects are also essential containment features.

In sum, the biotechnology industry is anxious to know the rules and the federal government is equally interested in understanding the genetic engineering industry. It appears that the regulatory bottleneck that has caused industrial set-backs and the deterrence of research projects will soon be dissolved. The regulatory structure being implemented for biotechnology will be more complex than those enacted for other disciplines.

KEY AREAS FOR SPECIALIZATION

The benchmark laboratory discoveries that were made in biotechnology in the early 1970s were accompanied by a great deal of enthusiasm. Scientists

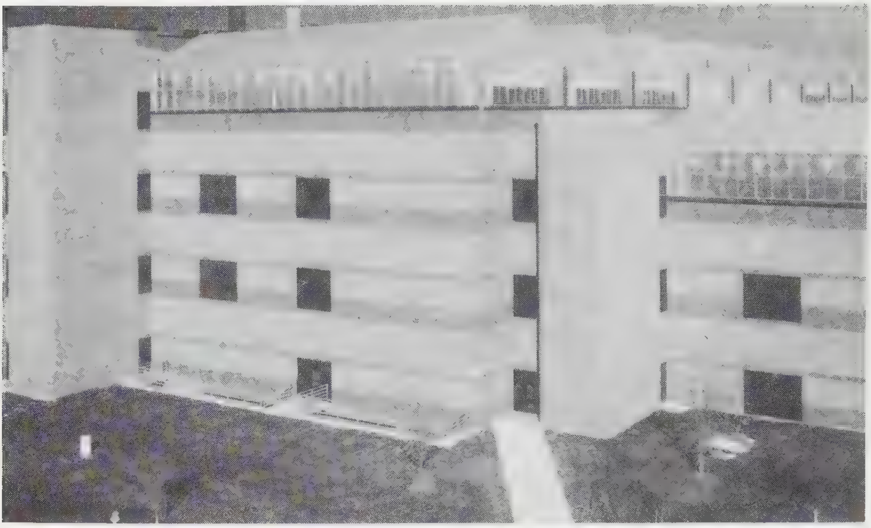

Figure 2.7 An array of rooftop greenhouses at Monsanto's Life Sciences Research Center in St. Louis. These structures house numerous plant growth chambers that are being used to test and develop new products for agricultural use. (Monsanto Company, St. Louis, MO)

and technologists made numerous utopian (having impossibly ideal characteristics) projections that were met with applause and public confidence. Genetic engineering was revered as the newest technology that had the potential to give us a world devoid of cancer, genetic diseases and birth defects. Biotechnology was introduced as the magical solution to world starvation and the energy crisis. We were told that gene splicing could be the ultimate fountain of youth—creating a world where the average age would be 100 years!

Amidst the revelry, however, a number of cautionary flags gradually appeared on the scene. People were reminded of the ethical issues associated with genetic manipulation. Visions of Frankenstein monsters, mutant animal species, and the accidental release of deadly viruses into the environment tainted the hopeful pictures that the proponents of genetic engineering had painted for us. Some of the more adamant critics drew comparisons between bioengineering research and the "eugenics" (a science dealing with the improvements of hereditary qualities) experiments carried out in Nazi Germany during the mid-twentieth century. The prospect of creating "super humans" did not provide a reassuring atmosphere.

Needless to say, much of the initial anticipation and hysteria alike have been diluted by time itself. Genetic engineering research projects have been allowed to take place in some cases and have been prohibited or delayed in other instances. Once again, we are confronted with a technology that is full of promise on one side and has the potential for disaster on the other. As you have seen, the concepts that underlie genetic engineering are far from simple.

The scientists and technologists who are aligned with research in this field possess some very profound and powerful ideas. The remaining sections of this chapter provide a brief synopsis of several contemporary issues that are pertinent to the biotech industry. Both sides of the debate are presented for your critique.

PROMISING BREAKTHROUGHS IN BIOTECHNOLOGY

AGRICULTURE. It appears that the second stage of the Green Revolution is now being waged in the world's fields and laboratories. Stage one occurred during the 1960s and 70s when scientists were able to raise crop yields dramatically through crossbreeding and hybridization. In many areas, those efforts eventually reached the point of diminishing returns. Larger and larger doses of expensive fertilizers and pesticides were required in exchange for only marginal increases in crop production. Biotechnology is the new star of stage two where scientists have the tools to direct evolution that may replace the conventional methods of simply exploiting nature.

The term **agrigenetics** has been introduced to describe the research and industrial efforts taking place in biotechnology with regard to modifying various plants and animals. Imagine a corn plant that resists the attack of predators such as insects, fungi, and bacteria. Envision varieties of wheat able to withstand drought and cold. Think about more nutritious strains of rice and soybeans. Try to think about the commercial possibilities of being able to engineer pigs that produce leaner pork chops and cows that provide specific grades of milk for different purposes such as high protein, low fat. Scientists who are actively engaged in agrigenetics research believe that the international future of agriculture appears to be much brighter due to these sorts of advancements. (On a somewhat informal note, a grammar school friend once wrote: "I'll love you until cows give chocolate milk!" Perhaps the time is approaching when that sentiment will be far less impressive?)

Visionary plant breeders are diligently working to engineer desireable traits into crops and ultimately break the "gene barrier" (producing wheat that possesses soy bean's ability to extract nitrogen from the air and convert it to fertilizer in its roots). Genetically engineered soil bacteria to enhance crop yields and reduce the need for chemical fertilizers are another potentially important aspect of agricultural biotechnology. Ultimately, we may even be able to genetically alter plants to enable them to produce raw materials (latex, starch, oils, sugar, cellulose, etc.) for the chemical industry.

HEALTH CARE PRODUCTS AND GENE THERAPY. The first antibiotics were discovered in the 1940s and stimulated the common use of such terms as "wonder drug" and "miracle drug." Once again, the pharmaceutical industry is on the verge of another revolutionary transition due to the almost daily discoveries being made in biotechnology. Researchers tell us that this new pharmacology will profoundly change the practice of medicine around the world.

Highly specific antibodies are being tested to fight cancer, prevent rejection of organ transplants, and treat multiple sclerosis. Numerous vaccines are being genetically engineered to treat malaria, genital herpes, and even tooth decay. These may become a major weapon against serious viral diseases. Gene splicing techniques have opened the door for substances that are only found in minute quantities in the human body to become major disease fighters. These products may ultimately be used to dissolve blood clots, treat hemophilia, and control stress. Modified versions of these organic substances show promise to block the production of enzymes to halt the dangerous side effects of diabetes, heal ulcers, and prevent chronic heart disease.

The mid-1980s witnessed the approval of genetically engineered versions of human insulin, the human growth hormone, and human interferon. A series of other promising vaccines, antibodies, and immunoagents were introduced for clinical trials during that period also.

Research continues in the field of gene therapy whereby several genetically transmitted diseases could be cured. Proponents of gene therapy believe that the process of transplanting healthy genes into the cells of patients who are suffering from debilitating and usually fatal diseases will provide renewed hope for their survival.

The first diseases treatable by retrovirus-delivered genes (removed from and reimplanted in the patient) will probably be single-gene disorders where the critical genes needed are found in accessible cells. To date, the only appropriate cells are found in the skin and bone marrow. One disease that is considered to be a promising candidate for gene therapy is Lesch-Nyhan syndrome. This is a rare disease characterized by cerebral palsy, mental retardation, and self-mutilation. It is caused by the absence of an enzyme in the bone marrow. Other diseases that were initially thought to be good candidates for gene therapy have since been categorized as more distant possibilities. Treating diseases where the critical genes needed are located in inaccessible organs like the brain is even further into the future.

INDUSTRIAL SUPERBUGS. Several environmental applications that have been cited for biotechnology include mineral leaching and metal concentration, pollution control and toxic waste degradation, and enhanced oil recovery capabilities. Although these applications may not reach the market for several more years, research continues on the genetic characteristics of some very useful micro-organisms. Around the world strange kinds of bacteria are found thriving in hot sulfuric-acid springs, briny salt pans, and burning soda deserts. Scientists believe that if industry could harness the metabolic talents that enable these "superbugs" to survive, it might discover a whole new array of chemical processes.

Microorganisms are already being used in pollution control. The potential applications of biotechnology to treat liquid and solid wastes seem promising. Industrial bugs have been developed for use in cleaning up PCBs, dioxins, and oil spills. Recombinant DNA techniques are being investigated to select micro-organisms that can degrade hazardous waste materials.

In the mining industry, biotechnology holds the potential for improving the strength and capabilities of microbes that are being used to leach metals from mine dumps. Some researchers projected the value of precious metals extracted via biotechnological means to be in the billions of dollars within the next decade.

Biotechnology may also enhance oil recovery procedures around the world. A significant percentage of the world's subterranean oil supply is either found as reserves trapped in rock or is too viscous to pump. rDNA technology may provide microorganisms that can be injected into these oil reservoirs to release the trapped oil.

BIOELECTRONICS. Another frontier to be explored in the biotechnology industry is called bioelectronics. This unique area involves the use of genetic engineering to make electronics from organic molecules. The potential for the use of proteins in electronic devices has been discussed due to advances in rDNA technology and the computer-aided design of proteins. Research is directed toward work in two areas—biosensors and biochips. Biosensors have desireable applications in medicine, environmental improvement, and the defense industry. The biological nature of biochips introduces some exciting medical uses, but research in this area has only just started. Though promising, bioelectronics is one of the more distant commercial efforts that has been projected for the biotechnology industry.

CONTROVERSIAL ASPECTS OF ADVANCEMENTS IN BIOTECHNOLOGY

Individuals who oppose further research and development in genetic engineering cite a variety of defensive reasons for their stance on this technology. Their concerns seem to fall into three general categories including:

1. Deliberate release of genetically engineered micro-organisms and plants into the environment.
2. Use of genetic engineering in human gene therapy.
3. Potential application of the technology to military weapons.

The advent of genetic engineering biotechnology has created a whole new dimension in our society—power and control over the genes of life and perhaps the evolutionary process. Some of the visible risks of genetic engineering include spontaneous mutations and developmental disorders in animals and plants. Increased susceptibility to disease is also probable. The deliberate release of bacterial pesticides may lead to long-term adverse ecological consequences. Conventionally used chemical pesticides have no independent mobility or reproduction capabilities. Therefore, their potential for causing adverse effects is limited. Microbial pesticides, on the other hand, may replicate and spread beyond the designated area of use. Due to the fact that these genetically engineered organisms are nonindigenous to the environment, they may not be subject to natural controls and dissipation methods.

One such organism that created a significant amount of public outcry was an alteration of a naturally occurring bacterium that produces a protein which enables ice crystals to form on plants (frost damage). Scientific advocates of this research indicated that this newly engineered organism would compete with the wild one and significantly reduce the frost damage which afflicts many crops each year. Several attempts to field-test this bacterium were curtailed due to the fear that it could spread into the atmosphere and drastically disrupt snowfall patterns.

Engineering plants to adapt and grow in climates to which they are not commonly adapted sounds quite beneficial at the outset. Conversely, these plants would probably be introduced into environments that were hosts for many foreign insects and diseases. Disruption of the ecosystem due to the introduction of novel plant life would follow since more chemicals would be needed to protect these species.

On another front, gene therapy offers enormous hope for the alleviation of human suffering. But the power to alter "nature's lottery" so to speak has introduced an ethical dilemma. Is it moral to tamper with the essence of humanity as we begin changing and rearranging genes? Should genetic researchers be allowed to alter germ line cells so that the patient's offspring would also be cured/corrected?

Critics of bioengineering argue that these types of experiments represent the desire to "play God" and should be strictly forbidden. Attempting to beat nature's odds and create a race of super humans is presented as a violent sin against the human race. If genetic engineers achieve a measure of success in their current research concerning altering genetic material to fix defects or eradicate diseases, will there be an irreversible movement toward designing a "perfect" baby? Many are fearful of this future scenario wherein the concept of a biological resume will be introduced at conception.

Finally, the perils of genetic engineering research surface whenever the discussion turns toward possible military applications. The chance that recombinant DNA technology could be used to produce biological warfare agents by creating new pathogens or modifying existing ones is certainly cause for concern. Genetic engineering affords the ability to produce vaccines to combat cellular assaults for which present vaccines are inadequate. Stated differently, technologists could develop an effective defense against biological weapons or make an attacking army immune to its own infectious agents. Toxins produced through rDNA technology could conceivably be used to wipe out selected plants, animals or human beings.

The U.S. Department of Defense has been initiating and sponsoring laboratory research projects involving rDNA techniques since the early 1980s. Charges that the Soviets may be developing biological weapons using genetic engineering generated heightened concern among United States scientists. If biological weapons are ever developed, it is likely that they will be much more deadly for civilians than for soldiers. Civilians do not usually have access to the same sorts of protection developed for military personnel. Furthermore, genetically altered bacteria directed at crops and livestock could lead to widespread famine. The future of biological warfare does not hinge on advancements in the genetic engineering field however, it depends more on the political decisions that are made with regard to its inclusion in military arsenals.

SUMMARY

Biotechnology has emerged from secluded research and development laboratories to join the ranks of business/industrial enterprises around the world. Startling developments in recombinant DNA procedures, monoclonal antibody technology, and bioprocessing techniques are taking place almost daily. Government is attempting to create a legal structure for coordinated regulation in this rapidly maturing industry. This represents one step toward maintaining the nation's international edge in biotechnology.

Genetic engineering is a powerful new technology that is characterized by a series of promises as well as an accompanying list of threats. Decisions are being made which may spell either ultimate relief or certain disaster for the human species as we know it. A synopsis of the pros and cons associated with genetic engineering research incorporates a wide range of disciplines including: pharmaceuticals, agriculture, energy, defense, animal husbandry, gene therapy, environmental protection, etc. As with other technological forces, society must manage and control the developments in genetic engineering with foresight that is based on convergent thinking and systematic decision-making.

DISCUSSION QUESTIONS

1. Explain some of the reasons that genetic engineering research has become a topic of technological controversy.
2. Why was the Escherichia coli bacteria chosen for use in early recombinant DNA research projects?
3. How is the production of monoclonal antibodies related to the cell fusion used in genetic engineering?
4. Explain what is meant by the title "scientist-entrepreneur." Give recent examples of other disciplines where this phenomenon has been evident.
5. Discuss some of the reasons that the task of establishing clear-cut regulatory guidelines for the genetic engineering industry has been so complicated.
6. In an attempt to determine the degree to which your academic contemporaries are up-to-date on the developments taking place in biotechnology, you are about to play the role of an investigative reporter. Randomly select five persons on campus and record their responses to these basic inquiries:
    a. Briefly explain what is meant by the term biotechnology.
    b. Are you in favor of further industrial research in the field of genetic engineering?
    c. Provide at least one reason for your stance on this issue.
    d. What is your academic major?

    Be prepared to discuss your findings in a discussion to be assembled in class.

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Chapter 3

ARTIFICIAL INTELLIGENCE FRONTIERS

DATELINE

Baltimore, Maryland

Westinghouse's Defense Center is applying artificial intelligence (AI) and expert system techniques to a variety of strategic military missions. One of the applications under investigation is a submersible vehicle that can go in and map a harbor, come back out and determine the optimum locations for the mines, and then go back in to deposit the mines and depart. Westinghouse has spent more than a million dollars of its independent research and development funds on this effort.

Westinghouse also received a prototype of an artificial intelligence inference engine processor that was built by the Xenologic Corporation of Berkeley, California. This device is expected to be able to perform 300,000 logical inferences per second. One of the Defense Center's first attempts to develop a rule-based expert system for troubleshooting proved to be somewhat inefficient. As a result, research team leaders decided to interview their test technicians; they discovered that nearly all of them carried a little notebook in their back pockets in which useful tips regarding prior experiences with each type of circuit module had been scribbled. The AI research team redirected its efforts to try to capture in the expert system the sort of experience-based information found in the technicians' notebooks—they named it an ''intelligent log book'' . . . .

INTRODUCTION

Human beings have been intrigued with machines and their internal mechanisms for centuries. Over the years, industrial designers and engineers have developed thousands of devices which have generically served to amplify or extend natural physioogical capabilities. Stated differently, machines might safely be described as inanimate (not endowed with life) “muscle amplifiers” for the human race. In many ways, it seems that mankind has ventured to recreate more powerful images and versions of himself in his machines.

Devising mechanisms that can lift more mass, exert more pressure per square inch or move more earth in an hour is the realm of industrial engineering. Most of us have little difficulty accepting a bulldozer as a good example of a machine that can perform a given physical task much more efficiently than a single person can. On the other hand, we may be inclined to raise an eyebrow if someone told us that the same bulldozer could make decisions on its own regarding which plot of ground should be cleared first, second and so on to complete the excavation. Bulldozers can’t think — or can they?

This concept of “thinking machines” is one that has been met with its share of enthusiasm as well as skepticism. It is a technological phenomenon that is embraced by a relatively new discipline that has chosen to label itself **“artificial intelligence”** or simply **AI**. In a general sense, artificial intelligence was born in the mid-1950s and was parented by the field of computer science. It has only been in recent years that professionals from a variety of disciplines have begun to recognize its potential for application in design, manufacturing, and production processes.

Artificial intelligence is presently regarded as a revolutionary development in the design and utilization of computer-based systems. Some experts project that AI systems will eventually replace human analysts, managers and decision-makers. During the early 1980s, the structure of the AI research and development community emerged from a two-decade period of laboratory/academic experimentation. Dedicated interest in the development of artificial intelligence has since produced a number of systems that have already been well received in business and industry.

What is artificial intelligence? There are many definitions cited for AI. This situation is largely due to the interdisciplinary (involving many academic areas) nature of its technical foundation. Artificial intelligence can easily claim its roots in all of the social, behavioral, managerial, industrial, and computer sciences. Using the technical perspective, AI includes robotics, speech recognition, image analysis, and the pursuit of epistemology. (From the Greek word for understand, the latter field involves the study of human intelligence in order to formulate rules that serve to explain the thought process.)

For many persons, AI simply implies computer-based problem solving such as theorem proving and number crunching. Others believe that AI systems are natural language processors that are capable of understanding free form, continuous dialogue. Some define artificial intelligence from the perspective of making machines perform tasks that would require intelligence if done by a human being. Still others cringe at images of “smart weapons,” “androids,” and “intelligent robots” when they are asked to comment on the subject of AI.

If we are capable of describing “non-thinking machines” as muscle amplifiers, why is it so much more difficult to accept “thinking machines” as knowledge amplifiers? This phenomenon, or dilemma if you prefer, is at the core of the ongoing computer science revolution. Philosophical debates will most likely continue regarding whether or not machines can *really* think. However, businesses and government agencies around the globe are anxiously attempting to develop artificial intelligence for practical applications.

In the near future, computer specialists may start helping us solve some of the great world problems that seem to evade the power of the human "experts." We may be able to construct supercomputers, expert systems, and biochips that can: prevent the outbreak of future wars; conquer a host of diseases; dissolve the world's energy crises; and solve a wide range of social and legal problems. Artificial intelligence may actually help make the human experts even better at their current jobs.

Computer skeptics see a gloomier picture as they stare through this looking glass. As with most technologies, AI is a powerful tool that brings with it the potential for disaster and abuse. Computer crime may excel to a level where our constitutional rights to privacy are invaded or even denied. The use of artificial intelligence systems in defense decision-making is cause for alarm since the malfunction of a five-cent chip could trigger an international war. And, of course, AI systems may ultimately displace millions of workers from their present positions of employment.

The discipline we label computer science or **cybernetics** emerged several decades ago as a study of the mechanized processes being used to convert raw data into a form of information that could be interpreted by humans. Current efforts focus on the conversion of information into knowledge and, ultimately, the conversion of knowledge into wisdom. This chapter examines the contemporary research and development efforts of the artificial intelligence discipline. As with other chapters in the text, you will be encouraged to focus on both the benefits promised and the threats posed by this technology.

1. What types of technological breakthroughs will be needed to bridge the gap between the limited computer "intelligence" that exists now and something approaching human capabilities?
2. Why has the mind/machine issue become so media worthy? What is intelligence? What is a machine? Can these two characteristics ever be used to describe the same entity?
3. What types of legal battles are projected to be fought due to the notion of intellectual property rights?
4. How can artificial intelligence systems be used to increase industrial efficiency or enhance personal safety?
5. Is there a role for artificial intelligence systems to play within the United States' defense strategies?

KEY CONCEPTS

In reading this chapter, you should endeavor to become more familiar with each of the terms and phrases on the following page.

Heuristics
Knowledge Engineering
Expert Systems
Inference Engine
Anthropomorphism
Parallel Processing
Intellectual Property
LISP
Cybernetics
Semantic Network
DARPA

TECHNOLOGIES ASSOCIATED WITH ARTIFICIAL INTELLIGENCE

After more than three decades, it seems that artificial intelligence has provided computers with the talent to mimic many human activities. However, there is still a long road ahead however toward enabling computers to emulate (to equal) genuine human thinking. This does appear to be the ultimate goal among many of the researchers who are currently employed in this industry.

The quest for "thinking machines" has fostered numerous projects around the world. Regardless of their origin, most AI systems projects have similar ambitions: 1) to pursue advanced research in artificial intelligence, 2) experimental computer architectures, and 3) improved semiconductor design with the ultimate goal of creating the first "intelligent" computer. Reaching this goal would represent a quantum leap over the functioning of several computer generations and the core technologies on which they were based. Early in the 1980s decade, the Japanese government coined the phrase "fifth generation" to refer to current developments in artificial intelligence and the computer industry of the future.

To understand the complexity of this label, a brief explanation of the previous four generations of computer technology may be helpful. The first generation was born in the 1940s with the use of vacuum tubes to construct the earliest (and cumbersome) digital computers. William Shockley's research team at AT&T Bell Laboratories invented solid state transistors in the late 1940s which marked the second generation of computers introduced in the 1950s. Third generation computers arrived on the scene in the 1960s with the innovation of integrated circuits. IC's were invented simultaneously by Robert Noyce at Fairchild Semiconductor and Jack Kiley at Texas Instruments. The present and fourth generation computers are superfast and are characterized by very large scale integration (VLSI) circuits (the use of super-miniaturized silicon chips).

Each of these earlier-generation machines was dependent on a single, central processing unit that executes its instructions one at a time. The fifth generation model will use a great many processors all operating in parallel. The Microelectronics and Computer Technology Corporation (MCC), a consortium headquartered in Austin, Texas, has identified several technical parameters that will define this next generation of computers. Besides the above mentioned parallel processing feature, other areas of advanced research include: knowledge-based systems, data base management, and human interface technology.

BREAKING THROUGH AI BOTTLENECKS

The Microelectronics and Computer Technology Corporation (MCC) was started up by competing United States corporations to develop technology pertinent to artificial intelligence frontiers. Under the direction of retired Navy Admiral Bobby Inman, MCC was formed in the early 1980s as a research and development consortium. Each of the private member companies had to raise a six-figure ante to gain acceptance. Additionally, they were each asked to pledge at least $1 million to support MCC's ongoing research objectives well into the 1990s. Several of MCC's associated members in the mid-1980s included: RCA, Honeywell, Sperry, Digital Equipment, Boeing, Martin-Marietta, Lockheed, National Semiconductor, and Motorola.

MCC scientists are intent on breaking through the bottleneck problems that seem to be plaguing further progress in artificial intelligence. Two of the fundamental problems identified by university computer specialists involve **knowledge representation** and **serial processing.**

One dilemma is specific to the development of SOFTWARE that can represent knowledge in such a way that the computer can access it when necessary. In the early days, AI researchers believed that intelligence, like physics, could be reduced to a few principle rules. The naivety of this assumption soon became evident when scientists found that a list of "general-purpose" problem-solving strategies was too weak to confront most significant (and ordinary) situations.

It became apparent that computers are fantastic devices for running through bits of information one by one, comparing them, adding, subtracting, and so forth. Regardless of the fact that they could do these things at phenomenal speeds, little of the human intellect can be simulated in that manner. Computer scientists have come to realize that a computer cannot exhibit "intelligent" behavior unless it possesses an incredible wealth of knowledge about the world and how it works. This is the kind of knowledge that every human being takes for granted and is often referred to as good, old-fashioned common sense.

Research efforts that have recently made inroads toward breaking this knowledge-based AI systems bottleneck include **expert systems** and **natural language processors**. Each of these technologies is discussed in more detail in the sections that follow.

The second major area of concern among AI specialists is sometimes called the Von Neumann bottleneck and deals with computer HARDWARE. The design for virtually all computers in use through the mid-1980s was introduced by mathematician and computer pioneer John Von Neumann some four decades earlier. The basic principle calls for physical separation of the computer's memory and its processor with some sort of communications link between them. This feature slows the machine down since the processing unit spends most of its time waiting for data to be retrieved from storage or sent back into storage.

It is unlikely that conventional computers of this description will ever attain the critical speeds needed to respond to contemporary complex science and engineering problems. Stated differently, Von Neumann computers are just too slow to demonstrate many kinds of intelligent behavior in real time. For instance, human vision requires the ability to process several billion bits of information per second. Cray-2, the world's fastest supercomputer in the mid-1980s, is capable of performing calculations at the rate of 1.2 billion per second. See Figure 3.1.

Several significant AI research projects that aspire to overcome the limitations of computers that perform their operations serially are investigating a technique known as **parallel processing**. Other researchers are fascinated with a computer design approach that is based on theories about how the human brain processes information. This topic is further discussed in proceeding sections of the chapter.

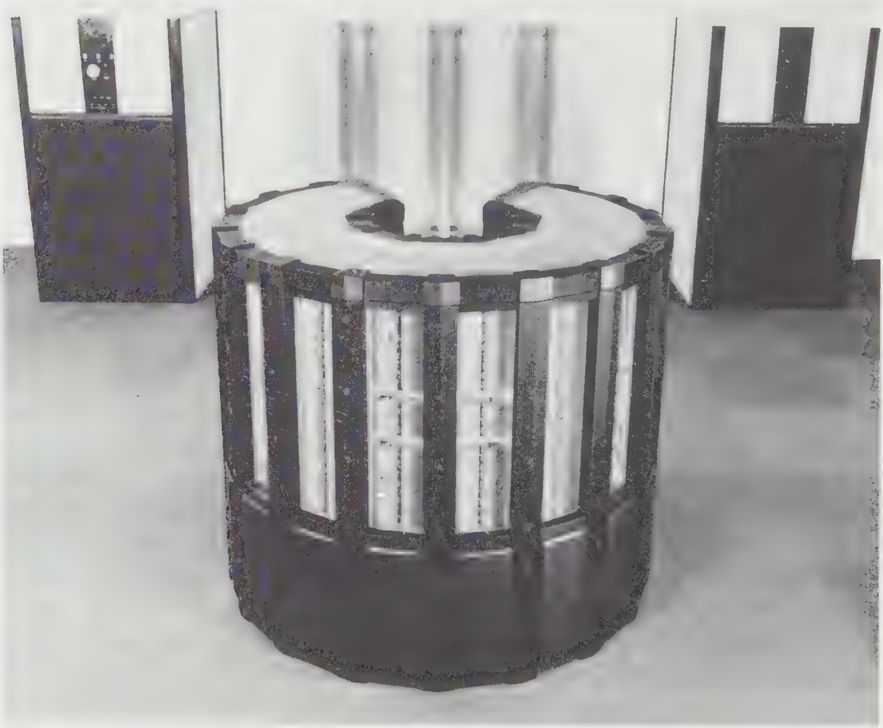

Figure 3.1 The CRAY-2 series of computer systems sets the standard for the next generation of supercomputers. Each of the four models of the CRAY-2 series is characterized by a large common memory, two or four back-ground processors, a clock cycle of 4.1 nanoseconds (4.1 billionths of a second), a liquid immersion cooling. The background processors can operate independently on separate jobs or concurrently on a single problem. The CRAY-2 systems offer effective throughput up to twelve times that of the CRAY-1 computer system and run an operating system based on the popular UNIX operating system.
(CRAY Research Inc., Minneapolis, MN)

EXPERT SYSTEMS

The dedicated work of numerous AI researchers has produced software programs that seem to exhibit certain aspects of human intelligence. These programs are called **expert systems** and can generally act as advisors or counselors on certain subjects. They presently exist for diagnosing medical problems, planning molecular genetic experiments, analyzing mass spectrographs, and inferring protein structures from electric density maps. In some instances, these expert systems have even been able to outperform their human counterparts. Although new systems are being released all the time, Figure 3.2 presents a list of several expert systems in use approaching the decade of the '90's.

Expert systems are actually an application of a mathematical system called propositional calculus. Programmers use it to construct a logic web that takes a collection of facts and selects from a predetermined set of conclusions. The resultant expert system consists of a "knowledge base" and an "inference engine." The **knowledge base** contains hundreds of if-then rules that are specific

A SAMPLING OF ARTIFICIAL INTELLIGENCE EXPERT SYSTEMS

EXPERT SYSTEM	GENERAL FUNCTION	SPECIFIC AREA
CALISTO	Management	Project Management
CRITTER	Analysis	Digital Circuitry
CRYSALIS	Data Analysis	Protein Crystallography
CSA	Intelligent Assistance	Nuclear Power Plant Configuration
DART	Diagnosis	Computer Faults
DELTA	Diagnosis	Locomotive Troubleshooting
DENDRAL	Data Analysis	Chemistry
ELAS	Data Analysis	Oil Well Logs
IMS	Management	Automated Factory Management
INTERNIST/ CADUCEUS	Diagnosis	Medical
KNOBS	Planning	Tactical Mission Planning
MECHO	Analysis	Mechanical Problems
MEDAS	Diagnosis	Medicine-Critical Care
MOLGEN	Planning	Molecular Genetics
MYCIN	Diganosis	Medical
NOAH	Planning	Robotics
PHOENIX	Auto-Programming	Oil Well Log Modeling
PROSPECTOR	Data Analysis	Geology
RAYDEX	Intelligent Assistance	Radiology
REACTOR	Diagnosis	Nuclear Reactor Accidents
SPERIL	Analysis	Earthquake Damage Estimate
SYN	Design	Circuitry Synthesis
SYNCHEM	Design	Chemistry
TECH	Analysis	Naval Task Force Threats
VISIONS	Image Perception	Vision
XCON/R1	Design	Computer System Configuration
XSEL	Intelligent Assistance	Computer Sales

Figure 3.2 List of artificial intelligence expert systems in use.

to a given subject area. For example, if you find this symptom, and this symptom, and this antigen, then the patient has XYZ illness. The **inference engine** is essentially universal in that it completes the logical reasoning to arrive at solutions to problems without being locked into one particular knowledge base.

When AI scientists discovered that the inference engine could be operational in several fields, they held on to the notion that at least some human reasoning is structural. Furthermore, machines could be destined to duplicate human thinking. When asked to characterize the "ultimate expert system," AI specialists listed the following attributes:

☐ They can solve problems.
☐ They can explain the results.
☐ They can learn by experience.
☐ They can restructure their knowledge.
☐ They are able to break the rules when necessary.
☐ They can determine relevance.
☐ They can gracefully admit to their own ignorance as they reach the limits of their knowledge.

Most expert systems developed to date could only exhibit the first three of these properties in any depth. AI researchers have only begun to scratch the surface in their efforts to incorporate explanation and knowledge acquisition features into these systems (learning by experience or through one's mistakes). In any event, the fact that computer programs exist that enable machines to solve problems and try to learn from their mistakes is truly a major accomplishment in the field of artificial intelligence.

Heuristics

Another aspect of the human thought process involves a fair amount of judgmental knowledge that is based on previous experiences. The scientific term for this type of knowledge is **heuristics,** from the Greek word for discover. AI researchers usually consider heuristics as the method of choice in designing new expert systems. Also called the art of good guesswork, heuristics give computer programs flexibility and a measure of creativity.

Heuristics enable human experts and machine experts to make educated guesses when necessary. Also related are the abilities to: 1) recognize promising approaches to situations, 2) break problems down into smaller parts, 3) and get around incomplete data. These general rules of thumb that human experts gain from their daily experiences are considered extremely important in the field of AI systems. Referring back to the DATELINE section of this chapter, AI specialists at the Westinghouse Defense Center recognized the critical need for the technician's notebook characteristic in designing their expert systems.

To make effective use of heuristics, programmers needed to develop whole new families of computer languages.[1] AI languages are different than conventional computer languages. AI programs incorporate data into the instructions in such a way that new knowledge can be added to the program without extensive restructuring. This dynamic feature encourages experimentation but consumes a lot of memory. Along the way, AI language developers also devised a technique for translating a human expert's experiences (medicine, chemistry, geology) into symbols that computers could understand. This process has become known as **knowledge engineering.**

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[1] See Shindler, Max. AI: Breeding the languages of tomrrow. *Electronic Design,* March 21, 1985, pp. 94-122. This report provides a detailed review of several AI programming languages that were either in use or being developed at the time.

One of the most common AI languages used in the United States is called LISP which is an acronym for List Processing Language. It is not like other languages such as FORTRAN or BASIC which had been developed primarily for number punching. LISP was first presented in 1959 and eventually became quite proficient at manipulating symbols such as English words and phrases.

LISP also has a built-in mechanism for linking symbols into concepts. The concepts can take the form of "if-then" rules, games, scripts, or "semantic networks." A SEMANTIC NETWORK is a pyramid shaped network of related ideas which deduces conclusions (e.g., all birds have wings, a sparrow is a bird, therefore a sparrow has wings). Each of these structures have been developed by AI scientists to represent human knowledge in forms that the machines can handle. Promising achievements have been obtained through the use of LISP in artificial intelligence applications.

A Sampling of Expert Systems

Expert systems are often sold in the form of empty "shells" which are software programs that can be filled with specific types of expertise. This "shell" is essentially the inference engine component of the system. One such system is called PROSPECTOR. It was developed at SRI International (Stanford Research Institute). PROSPECTOR's electronic-geology software has been used to locate ore deposits and mineral lodes around the world. It has demonstrated its ability to outperform expert geologists is some problem cases. PROSPECTOR receives input from a user regarding geological conditions. It then makes recommendations about the likelihood of finding mineral deposits in a certain site. The PROSPECTOR knowledge base contains nearly 1600 "if-then" rules.

Almost from the beginning, the medical profession has been a beneficiary of expert systems. The now famous MYCIN program can be used to diagnose certain infectious diseases—often better than human specialists. MYCIN was developed at Stanford University and its initial limitations or "bugs" provided useful guidance in knowledge engineering.

The first commercial expert system introduced into the field of artificial intelligence in the late 1960s was called DENDRAL. It still enjoys regular use by organic chemists internationally. Its knowledge base estimates the molecular structure of unknown compounds using advanced analytical techniques such as mass spectroscopy and nuclear magnetic resonance.

AI expert systems have also been developed with training and engineering applications in mind. STEAMER is used by the armed forces to teach naval officers, through simulation,the techniques needed to run a steam propulsion plant similar to those found on many ships. It was developed by the U.S. Navy Personal Research and Development Center in cooperation with the private firm of Bolt, Baranek and Newman, Inc.

DELTA is yet another expert system that uses its diagnostic strategies to identify and help maintenance workers correct malfunctions in diesel electric locomotives. This innovation came out of the research and development center efforts at General Electric Company.

An expert system sold by Syntelligence of Sunnyvale, California provides underwriting advice to commercial property insurers. A simplified medical diagnosis program called PUFF can interpret the results of certain pulmonary tests. It is used at the Pacific Medical Center to diagnose lung disease. This program is actually an offshoot of the earlier MYCIN. Teknowledge of Palo Alto, California, has developed a program to advise oil companies of what to do when a well bit gets stuck in a substrate hundreds of feet below the earth's surface. As more expert systems are introduced each year, the force of artificial intelligence will be felt in a growing number of scientific, managerial, medical, and technical disciplines in our society.

NATURAL LANGUAGE PROCESSOR

Some scientists believe that the real test for artificial intelligence is to enable machines to understand ordinary language when it is either written or spoken. In fact, getting computers to communicate in human languages such as English has long been a goal of computer scientists.

Work in natural language took notice of the fact that human language is not an abstract code. It is a complex and subtle form of communication. Language cannot be understood without a perception of context and an extensive knowledge of beliefs and expectations. AI research produced programs that can understand simple sentences with limited vocabulary. The word "understand" is used loosely here since most artificial intelligence researchers will concede that no program exists that can really understand ordinary language as human beings do.

A "smart" machine can electronically translate the sound of your voice into symbolic patterns. It can next identify individual words and phrases, analyze syntax, and contextualize them in its memory. Finally, it makes thousands of logical inferences and responds in the user's native tongue. The "correctness" and speed of the machine's response implies understanding. Critics of AI insist that the machine "understands" nothing at all—it merely manipulates abstract symbols in a fancy manner.

Even so, natural language processing systems do permit individuals to interact with AI and conventional computer-based systems in their language of choice. Natural language systems allow users to indicate what they want in a format that is similar to conversing with a colleague. Figure 3.3. identifies several natural language systems. Some of these are knowledge-based and are capable of drawing inferences and making decisions on their own in response to free-form input.

A Sampling of Natural Language Processors

One significant development in natural language processing technology involves the design and application of transportable natural language front ends. SRI International is one of several organizations that is working on Transportable English Access Mechanisms (TEAMS) that can be used with any Data-Based Management System (DBMS). The objective of TEAMS is to develop a natural language processing capability that can adapt to interacting with whatever data base is selected. Most natural language processors in the marketplace are specific to certain data base formats.

INTELLECT is a well-recognized natural language processing system that was developed by the Artificial Intelligence Corporation. IBM's decision to market INTELLECT was a corporate vote of confidence for the AI research community. INTELLECT permits users to interact with large data bases in a straightforward manner. INTELLECT allows "freeform" questioning rather than requesting data via a complicated query language. In other words, conversational English is the interaction mode used by these data base managers.

A SAMPLING OF NATURAL LANGUAGE SYSTEMS
DEVELOPED FOR USE IN ARTIFICIAL INTELLIGENCE

NATURAL LANGUAGE SYSTEM	GENERAL FUNCTION	SPECIFIC AREA
BROKER	Interfacing	Standard & Poor's Data Base Management
EXPLORER	Interfacing	Map Generation & Display
INTELLECT	Interfacing	Data Base Management
LADDER	Machine Translation/ Interfacing	Ship Identification & Location
MARKETEER	Interfacing	Market Analysis
NATURALLINK	Interfacting	Dow Jones Data Retrieval & Display
POLITICS	Interface Making	Ideological Belief System Simulation
SAM	Machine Translation/ Interfacing	Generic Story Meanings
SHRDLU	Interfacing	Location & Manipulation of Three Dimensional Figures
STRAIGHT TALK	Interfacing	Word Processing/Microcomputer Work Stations
TDUS	Interfacing	Electromechanical Repair
TEAMS	Generic Interfacing	Data Base Management

Figure 3.3 List of natural language systems developed for use in artificial intelligence.

NATURALLINK is a natural language interface to the Dow Jones News/Retrieval Service that was devised by Texas Instruments. Users of the service construct English language requests by selecting parts of sentences from the data base. The system then combines these parts into meaningful inquiries. NATURALLINK is designed to operate on micro-computers.

BROKER is another very powerful natural language front-end system. It was developed by Cognitive Systems, Inc. to simplify the procedures needed to access and search a large data base. Specifically, BROKER equips its users to easily retrieve information from Standard and Poor's Compusat data base. This "powerhouse" contains over twenty years of statistical, market, and financial information on several thousand corporations.

Research and development projects concerned with natural language systems such as these examples will continue to be pursued by AI scientists. The fruits of their labor will eventually close the gaps between the users of large data base management systems and the consumers of their output. Natural language front ends may make it easier to conduct "what-if" analyses in the process of solving a problem. Natural language systems may lead to the eminent demise of crisis management due to a lack of pertinent information at a given point in time. The further development of natural language processors may encourage managers and analysts to be more receptive to the use of "smart" computers to help them get through their daily routines.

PARALLEL PROCESSING

The current AI hardware effort that is primarily designed to overcome the limitations similar to serialized computer operations is called **parallel processing**. As previously mentioned, contemporary computer architectures generally use just a single processor. Japanese computer scientists are hopeful that their future computers will have as many as one million parallel processors working in tandem. Each processor would be working on a small component of the main problem simultaneously with all the others. The result would almost resemble an "electronic nerve network" that slightly approaches the complexity of the human brain. This concept is sometimes referred to among AI experts as **massive parallelism**.

There are several parallel processing options being explored by university researchers and several AI start-up firms in the United States. How many processors are needed? Is it preferable to use a lot of small processors or a few larger ones? How should the processors be connected to one another and to the main memory cells where the data are stored? Should the processors all execute the same instructions at the same time on different chunks of data? Conversely, should they execute different instructions and work independently of one another? Although there are presently no tried-and-true answers to these questions, most designers seem to agree that massive parallelism is the most promising avenue to achieve machine intelligence.

A significant number of groups are presently investigating the possibilities of parallel processing. For example, scientists at Columbia University are working on a machine called NON-VON (for non-Von Neumann) that may ultimately utilize 256 processors. Each of these would send out instructions to as many as a million tiny, memory-laden "slave processors."

Another impressive project is underway in Cambridge, Massachusetts at Thinking Machines Corporation (an M.I.T. spin-off company). Scientists here call their innovation the Connection Machine. Its distinctive feature embodies a unique communication network that enables some 65,000 simple processors to exchange information in the pattern best suited to the problem at hand. Each processor is much less powerful than a typical personal computer, but in tandem they are capable of executing several billion instructions per second!

At MCC in Austin, Texas, the parallel processing investigative research projects are receiving a significant share of the funding and appear to be among the more important ones at this consortium. New York University is developing an Ultracomputer that will consist of over 4000 powerful processors. Each of these will have access to a bank of memory modules through a switching network. The University of Texas' research contribution is called TRAC (for Texas Reconfigurable Array Computer). This multiprocessor approach will connect its processors to its memory modules via a network that activates circuits as they are needed. This feature will apparently increase the system's speed.

Each of these projects may hold the key to breaking through the architectural bottleneck. Research specialists at MCC are committed to finding a parallel architecture that will be useful in a wide range of applications. It must be adaptive to vision, natural language, common sense reasoning, and all of the other functions a truly "intelligent" computer will be expected to accomplish. Inroads toward the ultimate "thinking machine" are being made gradually, but there are still computer scientists who wonder whether or not computers will ever be able to think like all of us.

THOSE INCREDIBLE THINKING MACHINES

The discipline of artificial intelligence has matured considerably over the last three decades. Its scientific innovations are either already in our midst or lie on the horizon of the very near future. We have electronic sensors that recognize voice commands, enhance mechanical vision, and respond in a spoken language of sorts. As mentioned before, the forthcoming generations of computer software can be run through the use of plain English commands. Technical spinoffs will most likely lead to more "hands-off" interaction with computers in your automobiles, homes, schools, and offices.

Some of the more exuberant futurists suggest that we will soon have machines to advise us about our income taxes or what to do about our child's fever at 2:00 in the morning. Electronic tutors might improve our child's chances of winning a scholarship to attend a prestigious college. Perhaps our nation's highways will be traversed by trucks that drive themselves and unload themselves at their final destinations. These enthusiasts look ahead to machines that do almost anything that now requires "intelligence" when completed by a human.

The science of AI has followed a familiar course of other technologies to emerge onto society's center stage. In some ways, it seems that purely experimental laboratory exercises have been left behind. The marketplace has been graced with some interesting new products.

What sorts of descriptive terms might be chosen to make reference to a simple interactive dialogue between individuals? It is probable that words like intelligent, thoughtful, witty, creative, sarcastic, mindful, conscious, or rational would be among those found on the list. Can those same words be used to describe a similar event if it were a machine, rather than you, that gave the response?

One of the greatest battles that computer scientists have been forced to contend with over the years involves the paradox: "If machines behave like people, are they intelligent?" Why was the title "artificial intelligence" devised to identify this technical discipline in the first place? The word artificial itself evokes negative emotional reactions among the general public. Once again, what is artificial intelligence all about? Many computer science researchers themselves have been unable to agree about AI or about the notion of whether or not they have created machines that can think. What do you "think?" Can today's machines "think?" Will tomorrow's machines be able to "think?" Are you "thinking" right now?!?

THE ESSENCE OF INTELLIGENCE

Regular and routine use of the word intelligence and its derivatives in everyday conversation seems to dispel its ambiguity (uncertain definition). Consider the following statements:

Intelligent individuals are often successful in business ventures."
"Arthur is an intelligent scientist."
"Intelligence is a desireable human trait."
"I just had an intellectual conversation with Sheila."

At first glance, none of these phrases seems particularly strange or ambiguous. On the other hand, if asked to define what is meant by "intelligence," the concept may suddenly become much more elusive. A college classmate who was enrolled in a general psychology class once defined intelligence as whatever it is that intelligence tests are supposed to measure.

This brief explanation did not impress the instructor and seemed almost humorous at the time. However, the underlying premise to the statement may actually be quite serious. Is intelligence concerned with the manipulation of numbers and symbols? Does intelligence have any influence over creativity and inventiveness? Is intelligence related to practical events occurring in the world around us? Do we find intelligence in mental activity or in outward behavior patterns? How is intelligence related to other complex phenomena such as learning, willingness, or remembering? Educational psychologists who set out to develop reliable intelligence tests most probably struggled with each of these pressing questions.

In attempting to define any word or concept, let alone intelligence, one usually strives for completeness in the explanation. It is much easier to devise complete definitions for concrete subjects such as automobiles, dogs or briefcases than it is to explain the meaning of nebulous (indistinct) terms such as love, depression, or intelligence. Do we really need a definition for intelligence? Perhaps not. Maybe it is more useful to identify some of the mental and behavioral activities that are essential to convey the essence of intelligence.

After a fair amount of trial-and-error experimentation, AI researchers finally admitted that intelligence was more than the ability to prove certain theorems or play a championship game of chess. Intelligence seemed to have something to do with understanding the nuances (subtle distinctions or variations) of ordinary language. It involved a dynamic memory system that could be altered as a result of new experiences. Intelligence certainly entailed the ability to learn as a result of having made a mistake. It also involved transferring principles from one set of experiences over to another (for example, being reminded of your grandmother when you pass by the corner bakery).

The ordinary intelligence that most people hardly ever take notice of is also characterized by remembering as well as forgetting. The paradox here is that the process of remembering something indicates that it had, at one point, been forgotten. This feature of being able to forget is a special aspect of intelligence. If, for instance, each of bit of information that the mind needs to get through a single day were all equally clear and present at every moment, it is doubtful that the person would even be able to get to the breakfast table!

Forgetfulness is a blessing in the sense that the mind remains less "congested." The euphoria (feeling of well-being or elation) that one experiences after doing well on a written examination also exhibits the importance of "remembering" coupled with being able to "forget." In other words, intelligence allows the mind to stay on task (an exam in calculus) without worrying about unessential facts (the nutritive value of carrots) for the duration of the examination. An interesting aside here, computer programmers tend to support the notion that machines can not forget any of the information that they receive.

Researchers sometimes make a distinction between intelligence and intellectual abilities. **Intelligence** is perceived as the capacity to acquire certain skills rather than the skills themselves. Furthermore, the capacity to acquire these skills implies the potential for certain types of behavior. Stated differently, if we say that a person is intelligent, we are actually imagining how he or she will behave in circumstances that may not yet have occurred. The word skill as used here refers to numerous intellectual abilities including: judgement, comprehension, reasoning, adaptation, concept-formation, appropriate response, etc.

The essence of intelligence is indeed multifaceted. The emergence of artificial intelligence as a branch of computer science has stimulated a view of intelligence as an information-processing phenomenon. Contemporary AI research is focused on learning, reasoning, language understanding, translation, and so forth. The differences that exist between minds and machines are undeniable.

There are many types of human intelligence that machines may never be able to simulate (for example, recognizing an old friend on the street and wanting to tell him about your newest career change). In other areas, the future for applied AI in computer-based systems looks quite auspicious (favorable).

MINDS AND MACHINES

The act of imparting lifelike or human attributes to inanimate objects, technically known as anthropomorphism, is not uncommon. Most of us can recall saying something like:

"Just before Thanksgiving, the refrigerator DECIDED to go on the blink."
"The automobile engine is DEAD."
"This new computer HATES me!"
"The television set is BEHAVING like a TIRED old dog."

Contrary to what your neighborhood mechanic may have told you, car engines can not really die, nor can a refrigerator make decisions. Regardless of these realities, we usually do not think twice about the literal meaning of statements such as these. Computer scientists who are guided by the current user-friendly concept seem to have taken this practice one step further. Computers are being programmed to be courteous as well as helpful. A true incident may serve to illustrate this phenomenon.

> An elderly gentleman approached the automated-teller machine of a local bank with a certain amount of trepidation. It may very well have been his first experience with this now common aspect of contemporary technology. After a couple of tries, the man finally managed to correctly insert his bank card into the appropriate slot. The display screen next flashed the request: "Please tell me your personal ID code." The gentleman glanced at a small slip of paper that he had in his pocket, cupped his hand over his mouth and whispered the information to the machine . . . .

This individual, and others like him who experience temporary confusion while using automated tellers, are unfortunate victims of the bank's use of anthropomorphic language to make them feel comfortable. See Figure 3.4. Somewhat more intriguing is the question of whether it is actually possible for a machine to make us believe that it is both human and emotional.

If this incident is unsettling, rest assured that most artificial intelligence experts still say that their goal of building computers that can truly emulate human thinking is as elusive today as it was decades ago. Some specialists suggest that the previously discussed expert systems found on the market are a weak excuse for artificial intelligence. The limitations of conventional programming techniques are also evident in the field of robotics which has been referenced as a key application for AI. Unlike human minds, machines have not yet been able to attain a holistic (emphasizing the functional relationship between parts and the whole) view of the world.

AI researchers are forging ahead but they have just recently begun to explore this dynamic, holistic part of the mind. They have built programs that

Versateller

Figure 3.4 When banks first installed automated teller machines nearly a decade ago, many patrons where reluctant to place their ''trust'' in yet another technological convenience. The individual shown in the above photograph is obviously confused about the instructions that the computerized banking system is giving her. While many persons take this aspect of contemporary technology for granted, there are still a significant number of people who prefer to execute their financial transactions with a human teller! (Michael Dafferner)

can learn in a limited fashion. They have also built programs that can recognize things to a certain degree. They have even developed programs that can make analogies. This is certainly noteworthy since the human mind learns through analogy. Earning a high score on a standardized analogies test is also said to be indicative of intelligence. Nevertheless, none of these programs can enable a machine to begin to perform with anything like the ease of the human mind. Marvin Minsky, founder of M.I.T.'s pioneering Artificial Intelligence Laboratory, summed it up quite simply: "It is easy to make machines do what humans find hard, but difficult to make machines do what humans find easy."[2]

And so, the question of minds vs. machines continues to plague the artificial intelligence community. Can machines think? Will machines ever be able to really think? Are minds actually machines? One possible answer to these questions and others like them is:" Who cares? As long as the automatic teller machine does its job well, what difference does it make if it is thinking?"

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[2] See Minsky, Marvin. Why people think computers can't. *Technology Review*, November/December 1983, *86*, pp. 65-70, 80-81.

Another response is: "No, machines can not think. They will never be able to think because the thought process is too complicated." Still another reply to these questions is: "Yes, machines will think someday—but not the same way that we do."

In an attempt to get beyond the rhetoric and the philosophical mind-machine debate, try to focus on the peripheral applications that are related to the technology of artificial intelligence. It is possible that the rush to capitalize on the commercial potential of AI has eclipsed its more human applications. The creative software engineering that AI researchers are noted for has provided insight into how people think, read, understand, and create. Perhaps AI's most beneficial applications are in the education profession. Instructors may be enlightened with new and better ways to teach reading and creative writing. Artificial intelligence is part of the glorious desire to understand human thinking—it may eventually provide insights into how we can learn new things faster and remember the old ones better.

CONTEMPORARY APPLICATIONS FOR ARTIFICIAL INTELLIGENCE

The artificial intelligence community probably groans with disgust each time someone asks if their research has anything to do with "HAL." HAL, the endearing and later hostile computer in Arthur C. Clarke's *"2001: A Space Odyssey"* is one of the best known computers outside the computer industry itself. One reason that AI researchers might not approve of using HAL as any sort of example of their work is its tendency to raise presently unattainable expectations.

HAL represents a near-ultimate with regard to a computer system's ease of use. It is also quite probable that the person who coined the familiar term "user-friendly" had seen HAL in action (that is before he became "user-estranged"). Despite the AI specialists' objections, every functional capability that HAL exhibited in the film classic is now available, at least in embryonic form, in AI systems used by individuals, business, industry, and the military.

HAL could speak. Inexpensive devices called speech synthesis chips provide today's computers with this talent in an unrefined state.

HAL could see. Research in artificial vision and pattern recognition have produced vision-aided robots. Although this sensory feature remains quite primitive, it is ideal for highly repetitive assembly line and pick-and-place tasks.

HAL could understand ordinary spoken language. Current technology will allow you to equip a personal computer to "understand" and respond to spoken languages. The user creates the vocabularies which are still very limited. Present systems are also speaker-dependent, meaning that the user must train the machine to understand his or her voice. These speech input devices, as they are called, will someday have a wide range of potential uses in office administration, assisting handicapped persons, construction, inspection, quality control, and automobile design/safety. For example, sobriety systems that will make it impossible to drive a car if you have had too much to drink.

The following sections provide a synthesis of some of the artificial intelligence frontiers that will inevitably alter the manner in which international business operates and the profile of our daily routines. This topical coverage is certainly not exhaustive. The examples reviewed were selected to illustrate just a few of the many applications of artificial intelligence technology in contemporary society.

AIR TRAFFIC CONTROL

There is a research project being conducted at the Flight Transportation Laboratory of the Massachusetts Institute of Technology. Researchers here received funding from the Federal Aviation Administration to develop an artificial intelligence expert systems program to aid tower operators in monitoring and assigning runways at the nation's busiest airports. The project has been tentatively named Tower Chief.

Air traffic control requires a data base that can keep pace with and adjust to a dynamic environment. A primary objective therefore is to develop a program that is flexible and quickly receptive to modification. The human experts that will be called upon to assist in developing the rule-based system are experienced watch supervisors at Boston's Logan International Airport.

The AI researchers' efforts are directed at taking numerous variables that affect runway choices and sorting them out to aid the watch supervisor in decision-making. Decisions must often be made under pressure in the midst of some fairly unpredictable variables such as traffic, changes at other airports that may affect inbound aircraft, controller shift changes, runway repair or snow conditions, noise, preferential runway standards, prevailing wind patterns, visibility, and other weather phenomena.

Tower Chief will seek to develop a core structure that will permit relatively fast insertion of rules applicable to different airports. In other words, the expert system will not be tailored to only one airport. The application of artificial intelligence to the challenging world of air traffic control, where personal safety is paramount, will take a considerable amount of development and testing over the next several years.

NUCLEAR DISASTER SIMULATION

Recent nuclear disasters have stimulated a new urgency on the question of how to best monitor, analyze, and control a nuclear reactor in the event of an accident. Researchers at the National Center for Supercomputing Applications at the University of Illinois are attempting to fabricate a solution to this problem. At the center of their project is the combination of a parallel-processor supercomputer with the analytical capabilities of an artificial intelligence system. The supercomputer has incredible number crunching power. The AI system could simulate and analyze the chain of events in a complex nuclear accident faster than it would actually occur.

In the aftermath of the nuclear disaster at Three Mile Island investigators found that the operators made mistakes because they were unable to interpret the reams of complex data that poured in from the sensors. Since then, systems have been developed to give good graphic representations that make the data easier to comprehend. Even still, these systems cannot make predictions or offer advice.

The University of Illinois project has been amusingly named HAL-1986. The package is a general purpose inference system that does both forward and backward chaining. This means that it can either: (1) start with an initiating plant accident and determine the most probable outcome, or (2) take a plant failure situation and work its way back to find out what events may have contributed to the event.

It is projected that HAL-1986 will be able to perform a real-time simulation of the reactor operation while it continuously receives inputs from over 1000 sensors on an operating nuclear reactor. The AI portion of the program will run comparisons between the sensor data and the simulation to detect abnormalities. If an abnormality or accident does happen, the system will be able to simulate at "faster-than-real-time" speeds to forecast developments in the reactor system. It will also project the conceivable results of alternative actions.

It is expected that HAL-1986 should be available for initial industrial use sometime before the 1990's. Scientists stress that the package should not be envisioned as an automatic control system. It is being engineered as a monitoring mechanism and decision aid for "human" plant operators.

INTERACTIVE SOFTWARE

Computerized psychology is yet another by-product of the electronic age. The early 1980s bred the creation of a new genre of software that is geared to individual learning and behavior modification. Developers and researchers in this discipline have chosen the label INTERACTIVE SOFTWARE to describe their products, which are both adaptable and personal.

Several software firms are producing packages that are directed toward interactive involvement and behavioral engineering. Math Strategy is an example of this concept that is being used to teach math to children. Visualization is the key interactive feature of this program. The Mindreading Program is another package that was designed to help people determine whether a decision they are about to make is a good one or a bad one. The trend seems to be moving beyond the computer terminal to biofeedback monitors. One such product can gauge galvanic skin responses (electricity emitted through the skin, generally associated with sweating). Less sophisticated versions of this type of measurement system are used in lie detectors. Another device under study entails the biofeedback monitoring of eye movements to identify different states of thinking.

The emergent definition of interactive systems stipulates that the software be able to mold its communication to the individual computer user. Unlike earlier mindware programs that were geared to help us think better, become more organized, and psychoanalyze ourselves, interactive software programs are not static. Some observers believe that they represent the potential for new links between minds and machines.

TESTING AND PROCESS CONTROL

The test and inspection function in today's industrial centers is an area that is ripe for cost reduction. Testing operations are recognized as a factory function that has yet to be optimized. Instead of using testing to weed out bad products, testing should be used to head off bad products by anticipating and correcting process trends. The engineering premise is that a bad or uncontrolled process may be incapable of yielding good products.

AI technology is slated to make a valuable contribution to the testing functions through the incorporation of its expert systems in machine vision systems. See Figure 3.5. In this application, AI-based systems will make the random presentation of test pieces easier to handle. The flexibility of these programs will permit judgement of trends, reasons for trends, and best choices for corrective action. The compilation of these features will greatly enhance the testing functions beyond the rudimentary identification of acceptable pieces.

Due to its judgmental ability, AI will also find much work in process control. In the polymer industry for example, the ultimate goal is to develop controls that will not allow an injection machine to produce a single bad part (zero defect). Original equipment manufacturers (OEMs) are working to adapt artificial intelligence to the next generation of machine controls.

The Artificial Intelligence Group at Cincinnati Milacron is diligently engaged in developing new, more intelligent controls. In the future, they expect to incorporate AI into process control technology through the use of an AI-specialized computer. This peripheral device will process machine signals off-line. Further down the road, they hope to program process knowledge directly into the machine control itself. Symbolic artificial intelligence "if-then" language will be used in the software. This development will hinge on the introduction of the coming generation of very powerful VLSI (Very Large Scale Integration) microprocessor chips. The key to this event will be to perfect the fabrication of gallium arsenide (GaAs) semiconductors as a replacement for silicon. Procurement of intelligent process controls will serve to make future machines more predictable and foolproof.

INTELLIGENT WEAPONS

The United States Department of Defense established the Defense Advanced Research Projects Agency (DARPA). Most of the research into the use of artificial intelligence and robotics for the armed services has been under its jurisdiction. One of its high profile projects is a $600 million Strategic Computing Initiative (SCI). The proponents of this program seem almost obsessed with the perfection of computerized artificial intelligences that can guide unmanned vehicles, understand spoken English and plan battle strategy. It is the largest and most ambitious coordinated series of artificial intelligence projects in United States history.

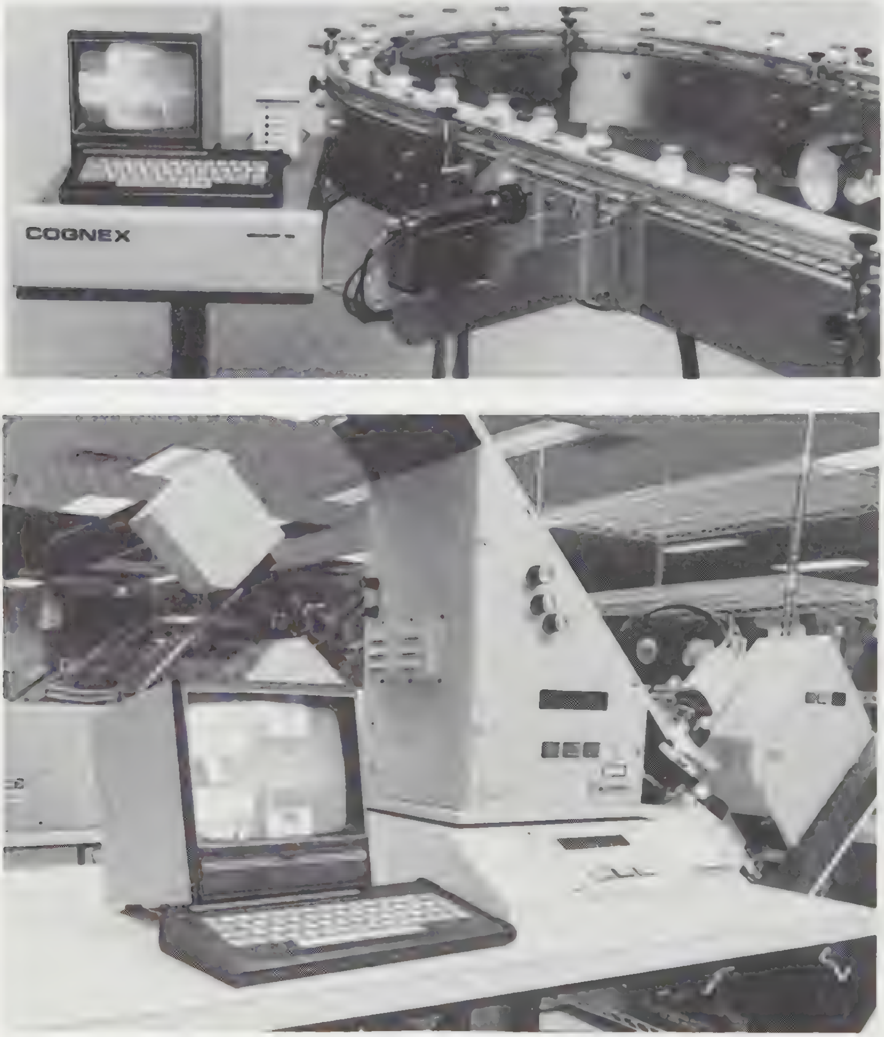

Figure 3.5 Cognex Corporation manufactures the first high level, single board machine vision system for OEMs, system integrators, and advanced manufacturing engineers With this system, users can design their own applications in inspection, gauging, guidance, and reading. This line of inspection systems brings a new level of consistency and objectivity to quality control. Shown here, checking bottle labels and caps and inspecting electronic component identification marks. (Courtesy Cognex Corporation, Needham, MA)

DARPA does not have laboratories of its own for research and experimentation. It depends on the facilities and services of computer science departments at many major universities and numerous large computer manufacturers. Military contractors including FMC, TRW, Martin-Marietta, Boeing, and McDonnell-Douglas are all heavily occupied with AI projects for DARPA.

S.C.I. research guidelines specified the development of a high-tech weapon for each branch of the armed services by the early 1990s. The Army has been promised a robotic land vehicle that will be able to navigate unfamiliar terrain and identify objects while traveling at some forty miles an hour. This type of machine could feasibly make reconnaissance missions or deliver supplies without any human involvement. If suitably armed, it could function as a tank. See Figure 3.6.

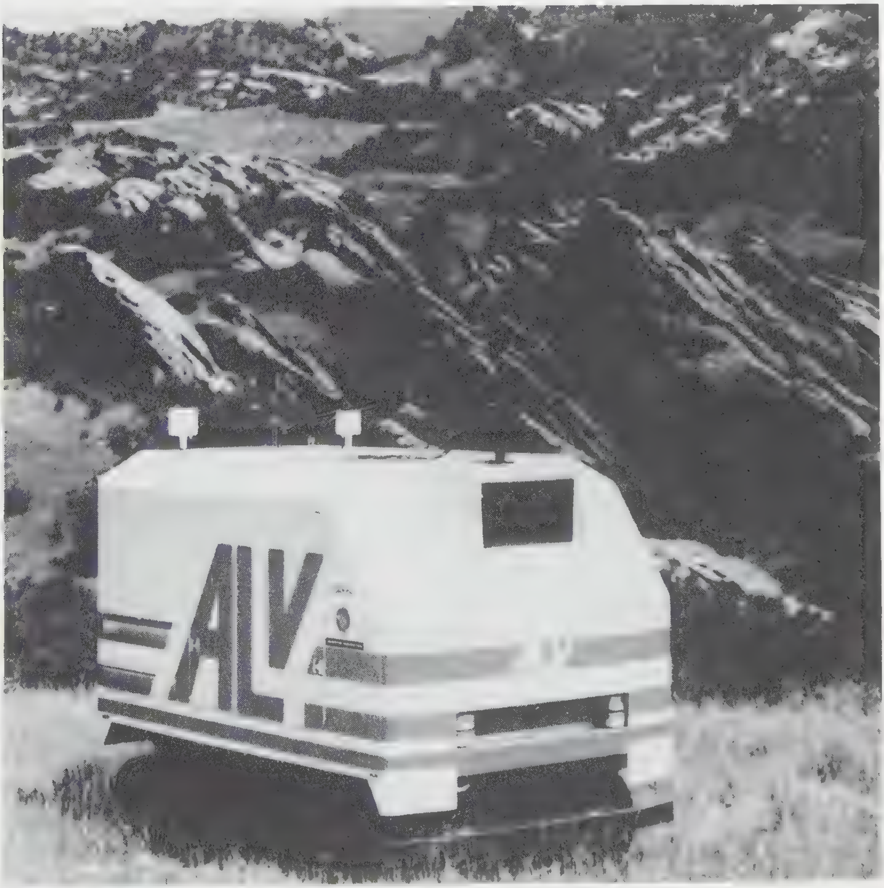

Figure 3.6 At Denver Aerospace, an autonomous land vehicle (ALV) is being developed as a national testbed for many aspects of artificial intelligence research. (Martin-Marietta Corp., Bethesda, MD)

For the Air Force, DARPA is working on a "pilot's associate" that will aid aviators in aerial combat. The system should be able to perform routine flight chores, store a body of tactical information, and even take evasive action to avoid incoming missiles. This device will converse interactively with the pilot in English amid the cockpit noise. McDonnell-Douglas is developing another system that will read the pilot's mind so to speak. By monitoring the person's brain waves, pulse, heartbeat, and other vital functions, the AI system will determine the pilot's alertness and how much information should be given out.

DARPA's project for the Navy is to devise a computerized combat management system for aircraft carrier battle groups. The system is destined to help commanders orchestrate a complex engagement at sea involving aircraft carriers, surface ships, submarines, and aircraft. It will be able to analyze intelligence compiled by the carriers' large array of sensors, plan strategy, and recommend actions. The capacity to provide estimates regarding potential damages and the likelihood of casualties is also proposed to be a feature of this system.

The success of the monumental S.C.I. project is contingent upon a series of technological breakthroughs that may never be attainable. To endow a machine with ordinary common sense reasoning will require a 10,000-fold increase in the storage capacity and speed of the most advanced computers. These superintelligent devices must also shrink in size and be able to withstand the rigorous environment of the battlefield. And then there is the cost factor which is still too prohibitive to sanction wide scale use in weapons.

Skeptics of the above defense-oriented projects fear that the S.C.I. may lead to military reliance on computers, making accidental conflict more certain. DARPA continues to forge ahead with its many artificial intelligence projects. It is convinced that even partial success in given areas will generate major advances in computer technology as we know it now.

THE INTELLECTUAL PROPERTY DILEMMA

The intellectual property issue pervades all areas of technological development whether it is bioengineering, manufacturing, communications, or medicine. It has become a topic of extreme relevance with respect to the electronics and computer industry over the past ten years or more. **Intellectual property** is commonly accepted as a general term that describes inventions or other discoveries that have been registered with government authorities for the sale or use by their owner. Some of the familiar related terms that fall into this category include: patent, trademark, copyright, and unfair competition

International conferences, task forces, and the like have been convened on numerous occasions to deal with all of these intellectual property issues. Strategies to prevent unfair competition have been simply discussed in some cases and have resulted in legislation in others. Unfair competition is a broad concept that loosely defines legal standards of business conduct. Statutes that fall within this heading are designed to provide protection against a variety of covert practices including simulation of trade packaging, using similar corporate and professional names, misappropriation of trade secrets, and passing off one person's goods as those of another. The United States position on intellectual property rights has been to intensify pressure on offending countries through consultations. Several government agencies are continuing their multilateral efforts to improve intellectual property rights abroad.

Several examples of this type of commitment to improving the sorry state of the situation were evident during the mid-1980s. The Trade and Tarif Act (1984) established a United States negotiating objective for the high technology sector. It specifically provides for minimum safeguards for acquisition and enforcement of intellectual property rights and the property value of proprietary data. It also authorizes the government to investigate complaints from United States businesses regarding lax intellectual property protection by foreign governments.

The enactment of the Trademark Counterfeiting Act (1984) imposed heavy criminal penalties for trafficking in goods or services that were found to bear a counterfeit mark. Before this legislation was adopted, counterfeiting was considered only a civil offense in the United States. The Department of Commerce has indicated that counterfeiting in its many forms has cost the United States anywhere from $8 billion to $20 billion in sales each year. It also has adverse effects on the employment opportunities for United States citizens. Perhaps the new criminal status of this offense will help reduce the loss of revenue and jobs to United States industry.

Another administrative initiative to deal with this predicament led to the proposal of the Intellectual Property Rights Improvement Act (1986). Its content mandated several changes to existing laws in order to close the loopholes enjoyed by foreign manufacturers. It should also make the enforcement of business rights less burdensome.

While the legislative rhetoric and debates continue, some concerns have surfaced on the computer industry front. It has become rather obvious that patent and copyright laws must be overhauled in light of sophisticated electronics and communications gadgetry. Rooted in the timeless traditions of the printing press, the old patent and copyright system does not seem to be versatile enough to deal with events that are unique to electronic machinery. Although the copyright laws were amended in the early 1980s to accommodate the needs of software writers, many problems still exist.

The Office of Technology Assessment (OTA) recently conducted a study entitled "Intellectual Property Rights in an Age of Electronics and Information."[3] In carrying out its research, this agency hoped to be able to forecast the kind of changes that might be necessary in order to keep the laws up to date with the revolution in electronics. Although some of OTA's recommendations are vague, they did suggest the possibility of creating an entirely new regulatory agency. It could be called upon to lend assistance in the impending battles over access to data, claims of authorship, and the integrity of products spawned by computer programs.

[3] *Intellectual Property Rights in an Age of Electronics and Information.* U.S. Congress. Office of Technology Assessment, Washington, D.C., 1986.

Questions surrounding the ownership, copyright and liability of electronic information are causing uncertainty among both computer users and vendors. Until recently, minimal attention has been paid to the legal implications of the ownership and responsibilities germane (relevant) to the electronic transfer of material. The use of personal computers and networks have become systematic. Questions regarding the ownership of database material or software liability have emerged. It appears that the field of information law is desperately trying to fit some entirely new technological artifacts into the existing, outdated legal framework. A few of the types of problems that are unique to recent developments in computers, artificial intelligence and electronics are summarized below:

1. Companies that are selling artificial intelligence expert systems may soon be facing the courts in the liability issue. Remember that these programs dispense advice through heuristic logic. Faulty software could result in suits concerning medical diagnoses, damaged drill bits, injured production workers, etc. Who would be liable? The vendor who sold it, the software writer, or even the human "experts" who were consulted to prepare the package?!
2. Existing laws may not be useful in addressing the conflicts between men and machines. Present law is vague on how to treat interactive programs where the computer and its user create an original work together. Let's say, for instance, a songwriter modifies a music-writing program and produces a hit song. Is the computer, or, better still, the original software writer entitled to share the royalties?
3. The ease and speed with which digital information can be copied is also creating new problems. Laser disks and advanced optical technology will enable the almost instant transfer of the amount of information contained in 100 novels to a site 100 miles away. Those 100 novels could then be copied and stored in a few seconds. Existing laws are not set up to strike an effective balance between piracy protection for new authors and the public's need for access to information.
4. In the motion picture industry, digitized pictures and soundtracks will probably create special scenarios. Computer technology will make it possible to resurrect dead movie stars (from old scenes that have been stored electronically) and cast them in new roles! Can you picture Clarke Gable holding the title role in the next episode of the "Star Wars" saga? In fact, California has already passed a law requiring that the heirs' permission be obtained in order to do this. Sorting out these future royalty claims should prove most interesting!

According to the Office of Technology Assessment, the courts are not well-equipped to confront the complex idiosyncrasies (peculiar characteristics) of the ever-changing electronics business. The best approach may be to cope with each technological case as it evolves and adhere to past principles. Perhaps Congress should make an attempt to fit each new technology into the existing legal framework. When this proves to be impractical, a new law could be enacted. This is essentially what took place when the novel Semiconductor Chip Protection Act (1984) was approved. It grants a ten-year protection to semiconductor chips and the architecture of the electronic circuits they contain.

Professionals who are in one way or another affiliated with the artificial intelligence discipline would be wise to keep abreast of legislative directives. It is all too clear that their ignorance in these matters could spell disaster for their present and future research and development efforts.

SUMMARY

Artificial intelligence is a branch of computer science that has come into its own limelight during the past several years. Artificial intelligence is loosely defined by some observers as the science that is attempting to enable machines to duplicate the characteristics of human intelligence. Toward this objective, we have witnessed the introduction of expert systems, natural language processors, and modified computer architectures

The question of whether or not machines can really think or should be considered intelligent remains unresolved. AI researchers have learned a great deal about how the human mind works, but they are still not convinced that it is truly possible to bestow the power of thought upon machines that process information. Applied artificial intelligence projects have begun to influence several professions including medicine, psychology, education, business, manufacturing, and the armed services. Although some incredible breakthroughs have been made, it may be several more decades before we receive widespread benefits from artificial intelligence.

As the tale of artificial intelligence continues to gradually unravel, the question of intellectual property protection will surface more regularly. The federal government's role in monitoring developments in this technology will most likely undergo changes in the years ahead. Its present legislative policies may give way to more stringent regulation. It appears in any case that artificial intelligence is and will continue to be a strong component of the computer science industry.

DISCUSSION QUESTIONS

1. Describe the distinctive characteristics that will differentiate fifth generation computers from those that were built during the first four periods of development.
2. Scenario: You are sitting in an airport restaurant waiting for a friend, and overhear the following conversation taking place at the next table:
   Waiter: Good afternoon sir. May I take your order?
   Customer: Yes. I'd like to have the spinach soufflé, but I have a plane to catch. What do you recommend?
   How would you interpret the meaning of that brief interchange? What types of "worldly" knowledge would a computer need to have in order to make sense of the dialogue?

3. Explain what is meant by the term heuristics. Detail at least two personal experiences you have had where your ability to be successful was based on this concept.
4. What is the technical objective behind the research efforts directed toward changes in computer architecture? Identify one label that has been used to describe these design changes.
5. Describe the similarities and differences between the concepts we refer to as "intelligence" and "learning." Are machines capable of possessing either of these traits? Why or why not?
6. This chapter briefly discussed the practice of using human attributes to describe inanimate objects. List several typical statements that you have used where mechanical or even computer-related terms were used to describe people.
7. Provide an explanation of what Marvin Minsky meant by his statement: "It is easy to make machines do what humans find hard, but difficult to make machines do what humans find easy." Use specific examples to illustrate your explanation.
8. How do you think the federal government should address the issue of intellectual property protection? Describe a few explicit actions and the methods that could be used to enforce them.

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Chapter 4

COMMUNICATIONS NETWORKS

DATELINE

Washington, D.C.

The Pentagon is trying to limit foreign access to government and commercial computer data bases that contain sensitive technical information. A range of legal and technological options including licensing access to high-tech data bases and planting special computer programs within the data bases to monitor who is seeking information are under exploration. Government officials have indicated that they face formidable obstacles in devising an effective and workable system.

Their efforts stem from a growing perception in the defense community that the export of high-technology data should be as strictly controlled as the export of high-technology goods. Foreign scientists have publicly confirmed their ability to regularly gain access to U.S. computer data bases through overseas telephone hookups. These data base systems provide data from such fields as biotechnology, electrical engineering, materials science and high energy particle physics. They enable users to retrieve, in a matter of seconds, reams of technical data that would usually require months of diligent library research. Data base retrieval has become an indispensable tool of the international research community . . . .

INTRODUCTION

Attempting to create a mental picture that presents a literal illustration of an "information explosion" would probably result in an image that is more humorous than realistic. See Figure 4.1. Many writers and social observers have used this **information explosion** concept repeatedly over the past few decades to refer to the rampant pace of technological change in communications. Information is commonly viewed as a basic resource for social progress

Figure 4.1 The sheer volume of information to which we have access in the fast-paced world of communications networks and technology leaves many of us feeling somewhat bewildered and incapable of absorbing it all! (Chuck Eichten)

and an essential ingredient for economic growth. An abundance of information can only be considered useful in either of these settings to the extent that it can be received, digested and utilized by the recipients who are most affected by it. The term "explosion" implies confusion, random distribution, and lack of control. It is no wonder that the information explosion concept carries a negative connotation in our society. In an abstract sense, we are forced to envision a social environment where persons do not possess the capability to make efficient use of the information that is available to them. In a distinct sense, the modes or methods we use to communicate with one another have undergone a tremendous amount of change and are eminently (remarkably) more powerful today than they were even a decade ago.

Information is the primary raw material of communication. In every sense of the word, communication has become an industry that makes demands on us. Intercontinental telephone calls are bounced off satellites and children feel more at ease with computer terminals and keyboards than they do with coloring books and crayons. Massive quantities of information can be accessed via an assortment of data bases and communication networks. In our modern high-tech world we are often expected to respond as quickly as computers. Our society has become increasingly reliant on the use of electronic information technology to transmit messages, store data and retrieve it back again—all in a matter of seconds. The information/communication industry itself includes those enterprises that produce electronic hardware and others that offer information services. It represents an essential component of contemporary United States industrial strength.

A few of the key developments that should be highlighted and reviewed during the course of any discussion that focuses on communications technology include: fiber optics, videotex, cellular telephone systems, facsimile transmission, and electronic networking. Each of these topics represents an entire industrial enterprise of its own but is inextricably linked to generic labels including telecommunications and information technology.

The marriage between computers and communication devices has also created new conditions of employment. Persons may have the opportunity to telecommute to their job site and totally avoid the hassles of traffic jams and the like. Numerous corporations have begun to investigate the benefits associated with video conferencing. Also known as teleconferencing, this method of communicating with each other is designed as an alternative to face-to-face meetings. For the geographically dispersed organization, teleconferencing addresses the problems of distance, crisis management, personnel time, and travel expenditures.

The combination of technologies that constitute this revolution in communications is still quite young. It is not only changing our world but changing the pace of change as well. "Software," "megabytes," "modems" and "floppy disks" are the main ingredients of many adult social conversations. These same terms are spreading through the vocabulary of today's teenagers who pride themselves in being able to pry open the computerized files of schools, corporations, and government agencies. It is the proliferation of computers in our society that causes alarm with regard to the security of information systems and individual privacy. Welcome to the information age!

The primary objective of this chapter is to briefly describe and discuss some of the changes taking place in the communications sector. Information technology continues to reshape the way we work, live, and play. We regularly come in contact with computerized goods and services—refrigerators talk, telephones are toted around in back pockets, banks accept withdrawals in the middle of the night, and people can purchase a computer for about the same price as a half-way decent set of bedroom furniture. Recognize also that the government's computer network is formidable and still growing—it could mean an end to your privacy.

Some persons express fear and anxiety regarding their inability to keep up with communications technology. Others are intent on riding out the wave of change and plan on digesting the resultant technological wizardry that emerges. There are those computer geniuses that cleverly keep abreast of each and every new development in communications and a host of others who simply do not want to be bothered with it at all. Regardless of the group you find yourself in, the topics presented here will probably sound quite familiar. Why? Because the structure of your daily routine is often affected by the success and/or failure of some computerized service or information system that you have little, if any, control over. In other words, you witness these technologies in operation each day. This chapter will address the following issues:

1. What effect have each of the following developmental technologies had on the profile of telecommunications in our society?
   Fiber Optics
   Videotex
   Cellular Telephones
   Computer Bulletin Boards
   Fax Machines
2. To what extent have major international corporations invested both time and money in teleconferencing?
3. How has the telecommuting option affected traditional employer/employee relationships and expectations in the work setting?
4. What effects are advances in information technology having on electronic record keeping activities?
5. Can individuals look forward to a day when personal privacy is once again considered secure?

KEY CONCEPTS

As you read through the various sections of this chapter, keep an eye alert for the following terms and phrases. You should be able to explain their meanings.

Videotex
Cellular Systems
Direct Broadcast Satellites (DBS)
Local Area Networks (LANs)
Electronic Cottage
Bandwidth Advantage
Facsimile Transmission
Fiber Optics
Teleconferencing
Interactive Video
SMATV
Roaming
Computer Blacklists

TELECOMMUNICATIONS TRENDS AMIDST AN INFORMATION EXPLOSION

Since the American Telephone and Telegraph (AT&T) Communications Corporation was deregulated and broken up, drastic changes in competition and hardware have characterized the telecommunications industry. New uses of existing technology quickly emerged to flood the market. Telecommunications equipment marketers believe that customer needs are finally coming into alignment with their sophisticated technology. This nation's telephone system was built over the last 100 years on an analog model. Subsequently, we live in an analog world where telephone, radio, and television are largely analog systems. Transmission channels and the signals they convey are typically classified as being either analog or digital.

An ANALOG SIGNAL is a continuous function of time and, at any instant, may have any value between the limits set by the maximum power that can be transmitted (for example, a bandwidth of 50 Hz to 15 kHz for radio broadcast programs). Cable systems and radio-relay systems equipped with linear amplifiers are good examples of analog channels. In order to transmit an analog signal without error, the channel must be a linear system. A lot of this is rapidly changing as computers are added to replace older components.

DIGITAL SIGNALS can only have discrete values. The most common digital signal is a binary signal having only two values (for example, "1" and "0"). Unlike analog channels, digital channels are not required to be linear since its output provides a specific number of discrete conditions that correspond to the input signal. A good example of a digital type channel is a telegraph circuit where the output signal is provided by the operation of a relay.

Data communication and voice-frequency telegraphy over telephone lines illustrates the process of transmitting digital signals over analog channels. Conversely, analog signals may be coded for transmission over digital channels by means of analog-to-digital converters. Today's telephone system is a dual system that operates in both an analog and digital fashion. Messages are transmitted primarily in analog mode throughout the system, while control or supervisory signals are sent digitally in the message system itself as well as along separate pathways. For better or worse, the technologies of communications and computers have been joined together to replace older components.

There is little doubt that personal computers (PCs), more than any other office tool, have had a significant impact on the way American business works. Numerous companies and educational institutions have installed PCs expecting an immediate increase in productivity. Oddly enough, the dramatic increase in productivity did not occur as projected. It became necessary to create a network that would enable these individual users to share information via some sort of mainframe data base. The ability to harness the computer's power was dependent on linking PCs together by a local area network or LAN.

A LAN is a series of cables (either coaxial or fiberoptic) and boxes that provide data communications links between computers in the same work area, building, campus, business park, etc. Local area networks allow computers, modems and printers within a single location to communicate with each other directly at very fast speeds. Until a LAN is installed, only computers and peripherals that are directly wired to each other can interface and interact. At the end of 1985, The International Data Corporation found that over 60,000

LANs had been installed across the United States. Even still, they also found that only 4 percent of all computer work stations were actually linked into a LAN. This figure is projected to increase to 12 percent by the early 1990s when over 500,000 LANs will have been activated.

Enabling computing devices to share and exchange information takes more than wires and switching mechanisms. It also requires several types of software. **Teleprocessing software** takes care of data entry tasks. **Timesharing software** allows several users to access a computer simultaneously. **Communications software** promotes the exchange of information between personal computers and mainframes. **Terminal emulation software** makes a PC "look" like a terminal so that a mainframe can communicate with it. Links between micros and mainframes require another step. File structures must be translated to help PC users request useful data from the mainframe.

Most computer users still move data between computers with the help of the "plain old telephone system"—sometimes called POTS. As previously mentioned, the phone system was designed decades ago to send voice signals, not data signals. This fact explains the need for so many machines to prepare a computer's bits and bytes for transmission over voice grade phone lines.

Following the deregulation of AT&T, the pressure to implement digital techniques into the nation's telephone system intensified. Companies started to attach computers to the phone lines and the boundary between the telephone and the computer lost its definition. In order to get better transmission quality at a cheaper price, digitization became a high priority. It is projected that approximately 30 percent of AT&T's long distance facilities and 90 percent of the Bell System's toll switching equipment will be digital by the early 1990s. Digitizing the "local loop," otherwise known as the "last mile," of the network may take many more years.

Subsequently, some firms have started to investigate several technological alternatives that will allow them to bypass the telephone system. Companies already have the capacity to construct their own private networks using microwave satellites, mobile cellular telephones, and fiber optics. They can also opt for bypass services like public electronic mail and value added networks. **Public electronic mail** is a computer-based communications system which digitizes voice messages and then stores them in a specialized mainframe computer for retrieval. **Networking** is a growing and changing technology that will spur the achievement of full computer connectivity. This will enable corporations to more efficiently: extract data from remote, heterogenous files; transfer files and extract between modes; access external computing services and data bases; and interchange documents. The climate of telecommunications in indeed changing. There are a number of independent telecommunications equipment suppliers who are anxious to provide opportunities for interested parties to take advantage of these new technologies.

At the heart of current telecommunications technologies is the desire to improve the capability of the nation's voice-oriented telecommunications system in order to transmit large amounts of data between computers. Two strategies that seem to be central to this objective involve the digitization of the telephone system and the development of more and better kinds of data communications. In all likelihood, these two technical thrusts will eventually become one. This will become a reality as soon as: (1) both voice and data communications use a common computer-based system and (2) communications lines and equipment become capable of transmitting both voice and data signals. In fact, several vendors have already begun to market and sell computer-based voice messaging systems that allow callers to record messages and leave them in "voice mailboxes" when the person is unavailable. Fiber optics is the telecommunications industry's response to the demand for systems that can transmit voice and data faster and with less distortion than current microwave systems.

FIBER OPTICS TECHNOLOGY

Lightwave communications emerged onto the scene in the early 1970s when researchers at Corning Glass fabricated a useful lightwave conduit. It was introduced in the form of a glass fiber about the diameter of a human hair. Communications industrialists were immediately attentive since optical fiber offers an enormous bandwidth advantage over electrical transmissions. Specifically, the **bandwidth** of a communication channel is a measure of the range of frequencies supported. This number is critical in that it determines the information capacity of the medium. The bandwidth of a lightwave fiber is about a million times greater than a radio channel.

The first commercial optical-fiber transmission system went into service in 1977. It operated at 45 megabits/second with multimode fibers, AlGaAs (Aluminum Gallium Arsenide) lasers, and silicon detectors. Rapid advances in technology soon made these first-generation systems obsolete. In less than a decade, fiber optic technology bolted from the laboratory to become a dynamic and pervasive force of change in the communications field.

Since the late 1970s, there have been dramatic advances in the amount of information optical fibers can carry and the speed at which the transmissions can occur. The experimental record evident in the mid-1980s was four billion bits of information transmitted each second over a span of 117 kilometers. This "payload" approximates the quantity of information contained in a 30-volume Encyclopedia Britannica traveling from Baltimore to Washington, D.C. and back in one second! In the future, fiber optics could very well replace both satellites and copper wire as the medium of choice for most of the world's communications requirements.

An optical fiber system consists of three basic components: 1) transmitting equipment that transforms electronic signals into light pulses, 2) the optical fiber itself, and 3) some form of receiving gear that acts as a light detector. The fiber is an amazingly thin strand of pure glass usually made of silicon or other material such as germanium. This glass strand consists of two parts: a light transmitting core and a layer of cladding that keeps the light from straying. Impulses are generated either by laser or light-emitting diode (LED) equipment. Lasers seem to more well suited for long distances because their signals travel further without the need for boosting. LEDs, on the other hand, are more reliable and less expensive.

To transmit conversation, a fiber optic system converts voice signals (which are electrical impulses that copy a caller's voice) into digital information. See Figure 4.2. When computers are the ones doing the "talking," the conversation is already in digital form. A laser beam or LED next converts the digital code (a stream of "on" and "off" signals) into light pulses that pass through flexible glass fibers. Unlike electrons, these photons are immune to electromagnetic interference such as caused by lightning or hair dryers. Since they do not create electromagnetic fields, fiberoptic cables cannot be tapped by inductive pick up devices. Consequently, the messages are ultimately transmitted with almost no loss of information and no addition of distortion.

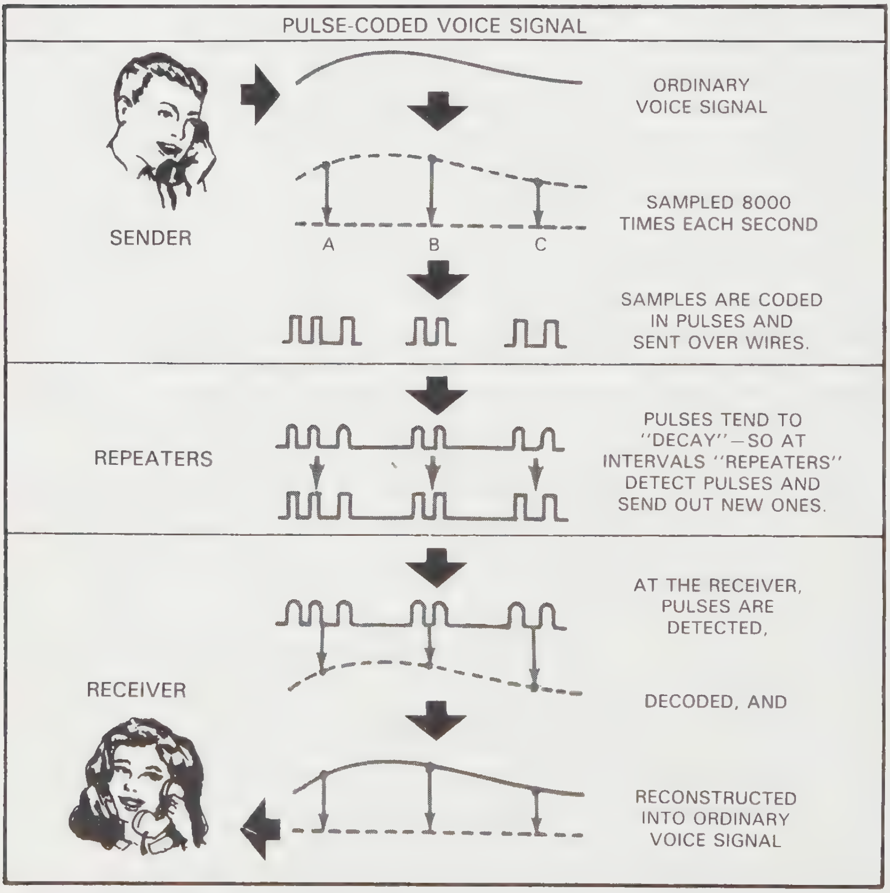

PULSE-CODED VOICE SIGNAL
ORDINARY VOICE SIGNAL
SENDER
SAMPLED 8000 TIMES EACH SECOND
A
B
C
SAMPLES ARE CODED IN PULSES AND SENT OVER WIRES.
REPEATERS
PULSES TEND TO "DECAY"—SO AT INTERVALS "REPEATERS" DETECT PULSES AND SEND OUT NEW ONES.
AT THE RECEIVER, PULSES ARE DETECTED,
RECEIVER
DECODED, AND
RECONSTRUCTED INTO ORDINARY VOICE SIGNAL

Figure 4.2 Basic diagram showing how a conversation is transmitted via a fiber optic system.

The first commercial fiber systems were used to link up telephone offices within metropolitan areas. The installation of long-haul fiber systems ensued with corridors in the Northeastern United States and in California. The first fiber submarine cable will connect the United States, England and France. A similar system is planned for the Pacific Ocean where undersea fibers will link islands with nearby mainlands. The extension of fiberoptic cable into your home (the local loop) is the next probable step. It is one that is made difficult by economics rather than technology. Copper telephone wires and coaxial CATV cables presently serve the market with an economy that fiber has not yet been able to match.

Technologically, the most significant limiting factor of fiberoptic cabling involves the connections between it and computers, terminals, and printers that are controlled by conventional electronics. Signals that are carried by fiberoptic cabling must be converted by transceivers from light energy into electrical energy in order to be understood by the processing hardware. However, lightwave signals are diminished when the fiberoptic cabling is interrupted to connect new hardware. Fewer than ten of these connections will weaken the signal so that it becomes unusable. Research and development directly related to this limitation should prove successful within the next few years.

We may soon reap the benefits of fiber technology in the home—two-way videotelephone may actually become economical. It could provide image material instantaneously allowing household residents to browse through television the same way they leaf through magazines. Several governmental agencies and the military are developing large fiber networks containing intrusion-proof information systems (recall the DATELINE segment of this chapter), computer-to-computer links, and local area networks. Many experts seem to agree that it is only a matter of time before much of the nation's copper is replaced by fiber optics. Until then, the two technologies will continue to coexist and serve a multitude of telecommunications demands.

CELLULAR TELEPHONES

During the mid-1980s, the cellular telephone became one of the hottest options available on luxury automobiles. See Figure 4.3. In fact, Jaguar dealers reported that they offered only two options: a cellular telephone and a highly sophisticated alarm system. One might make the assumption that selecting the first option necessitated investing in the second! 1985 marked the period of explosive growth for cellular telephone technology. In that year, the Federal Communications Commission (FCC) permitted 65 new systems across the country to go live. Their actions essentially quadrupled the number of United States cities that could enjoy the benefits of mobile telephone service. Current FCC regulations require that there be at least two competing cellular phone services in every major market. The FCC allows one wire line (a telephone company) and one nonwire line (a radio communications company) to operate in each cellular market area.

Figure 4.3 Individuals are becoming accustomed to conducting business from their automobiles. Until recently, few options were available to people in need of mobile communications. Cellular telephone service offers the advantage of portable communications. It is an obvious competitive advantage for executives who travel or owners of small but busy businesses who need convenient telephone access. (GTE Mobilnet, Inc.)

Directly after the FCC first authorized nationwide cellular service in 1982, cellular radio was earmarked as a technology that would make mobile communications as available and reliable as regular telephone service. While cellular technology is a modern innovation, automobiles have been equipped with radio-based mobile telephones since the mid-1940s. These pioneer systems seem primitive by today's standards due to several major drawbacks. Mobile telephones were tied together with a sky high transmitting tower which generally provided coverage within a 50-mile diameter. These huge towers required extremely high broadcasting power (generally as high as 250 watts) and typically handled no more than a dozen channels. This meant that only 12 users could transmit a call at any one time.

As a result of the marriage of computers and radio technology, many of these drawbacks have been reduced or completely eliminated. Cellular calls are presently composed of 90 percent computer interaction and only 10 percent radio transmission. The user's voice is actually the slowest piece of data being transmitted during a call.

In a cellular telephone network, the system operator divides the area (usually a city) into a series of small geographic units called cells. These cells "honeycomb" with each other to cover the entire area. See Figure 4.4. Each cell is equipped with one or more radio antennas and a low power transmitter. Cells typically cover a radius of two to ten miles. The primary advantage of this intricate design is referred to as **frequency reuse.** In other words, each cell transmitter is only powerful enough to communicate with the radio telephones in its own cell. Other transmitters in distant cells can use the same frequencies at the same time to communicate with mobile telephones in their cells. This technical phenomenon accounts for the enormously increased number of users that this type of system can accommodate at any given moment.

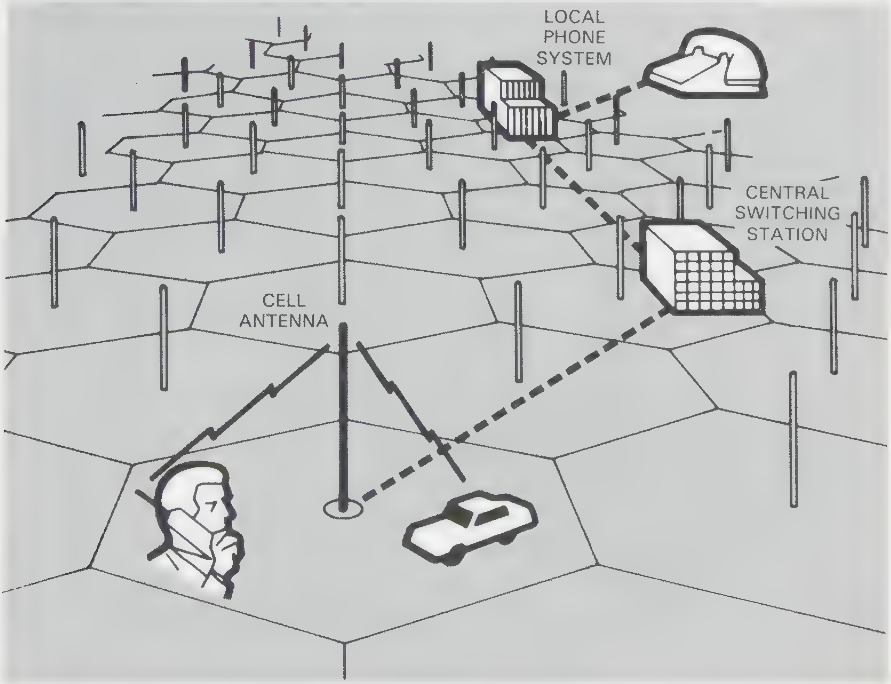


Figure 4.4 The system is based on dividing a metropolitan area into one or more radio coverage areas called cells. Each cell has an antenna capable of receiving and transmitting many calls simultaneously on low-powered transmitters. A person with a cellular phone can place calls from a car, a building, or just walking down the street, to other phones (cellular or regular). As the person moves from one cell to another, computers at a central switching station transfer signals unnoticeably from one antenna to the next as needed to keep these signals strong. Cells may, initially, measure up to 20 miles across. However, by reducing the size of cells and addingg transmitters, the system can handle hundreds of thousands of subscribers. The great advantage over traditional mobile phones is the potential for thousands of simultaneous calls. (Motorola Inc.)

Cells commonly have about 50 channels available for use. As the phones become more popular and users experience difficulty tapping into an open line, the cells can split and multiply. Figure 4.5 provides a diagram to show how cell splitting is a straightforward way to keep up with growing demand for service in a cellular system. Adding more transmitters and increasing the number of channels enables the system to handle many more calls.

Refer back to Figure 4.4 for a simplified explanation of how a mobile telephone operates in a cellular system. As a vehicle in which a telephone call is in progress on a particular channel moves from one cell to another, the call is automatically transferred to the neighboring cell. At this point, the call is conducted on different frequencies to which both mobile and fixed transmitters and receivers are automatically assigned. The key to efficient operation of cellular-radio communication resides in the computer control systems housed at the mobile telephone switching office (MTSO). Almost like magic, these computers routinely switch calls from cell to cell, assign channels, monitor the strength and quality of conversations, and process billing statements. The transfer of calls from one cell to another should take place without the user's awareness. There should not be any break in the conversation or any perceptible difference in the quality of the communication. This transfer function is usually referred to as the "handoff."

Cellular technology is expanding into increasingly more sophisticated phases. Enthusiastic equipment dealers and manufacturers envision the transforma-

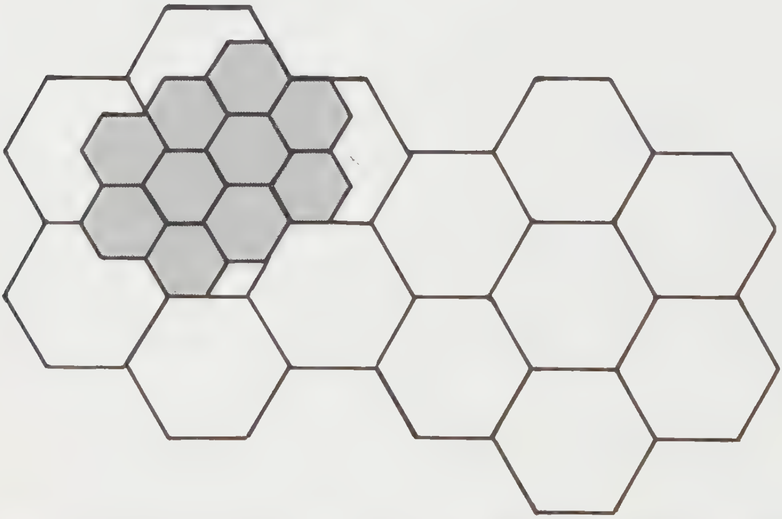


Figure 4.5 ''Cell splitting'' is the most logical way to keep pace with growing demand for mobile telephone services in a cellular system. This simple diagram shows how ten cells have been created out of the parts of 4 existing cells. Additional service can be offered as soon as low-power transmitters are activated in these newly created cells.

tion of the automobile into a moving office where executives, sales, or service representatives are accessible at all times. There are already a variety of portable briefcase cellular phones on the market and nautical installations have also become a reality. One cellular modem can transmit data from a lap top computer. The product is known as "THE BRIDGE AND SPAN" device. The BRIDGE accompanies the portable computer and plugs into the cellular telephone, while the SPAN attaches to the host computer.

Operating companies have also begun to work together to write "roaming" agreements that allow mobile phone users to drive to other areas and still use their phones as if they were on their home territory. Prior to these agreements, mobile customers had to call the system operator in the host city to request that their phones be activated. Credit card numbers were essential since the early MTSO (mobile telephone switching office) computers were not equipped to send the billing back home. Roaming makes cellular telephone usage a great deal more flexible and convenient.

In spite of all the breakthroughs, cellular technology still has a way to go, and so do the people who use it! Accident data are inconclusive, but cellular technology has stimulated a debate regarding safety. Chatting at the wheel may be too distracting during metropolitan rush hour traffic. Insurance companies have started to reveal concern about their liabilities—from both the risk of accidents and from thefts of cellular phones. Most telephone manufacturers urge customers to pull over when placing or taking calls. In some ways, this recommendation seems to negate the whole reason of investing in such a device in the first place. Your personal observation will show that this advice is normally not taken by most of the persons using cellular telephones.

FACSIMILE "FAX" TRANSMISSION

Since information is the operational core of our modern society, millions of documents and messages are sent daily in a number of ways. Each of us has, at one time or another, had experiences with the United States Postal Service, Express Mail Companies, and computer-based electronic mail services. The first and second examples are dedicated to the delivery of the original document, while the third transmits character information.

Another way to deliver a message is to electronically transmit a visual image of the original. This image communication technology creates a bit-map (digital) representation of the original which can include text, graphics, and/or photographs. This method of sending information from one point to another is labeled facsimile transmission or simply "Fax."

Not too long ago, some business analysts referred to facsimile as a stagnant technology with a dismal future. The most often voiced complaint against facsimile was that it was so slow. Some systems required up to six minutes of expensive long distance time to transmit a single-page message. Early machines were often difficult to operate, incompatible, noisy, and expensive. Furthermore, the document quality was commonly less than acceptable.

In recent years, universal standards, improved capability, faster speeds, and reduced equipment costs have had a significant impact on the population of fax machines in the business world. An increased use of computer technology in fax terminals has made facsimile an attractive form of electronic mail. Facsimile has several advantages over other forms of data transfer:

☐ It does not require keyboarding.
☐ It can be faster and more accurate than telex, communication word processors, or computer-based message systems.
☐ It is generally less costly than other forms of electronic mail.

Fax is a relatively simple communication system to design and switch on since it typically makes use of existing telephone networks to handle most of its traffic. It is possible to go on-line with a terminal, an electrical outlet, and a telephone. The array of terminals available is as diverse as the number of applications desired. Selecting the most cost effective equipment is not an easy task.

Fax manufacturers have attempted to be attentive to differing user requirements by building systems that offer a variety of features to fulfill a wide range of customer needs. Some models are analog while others are digital. Analog units may provide any or all of four communication speeds ranging from two to six minutes for each page transmitted. Digital models come equipped with a variety of modem speeds from 2400 baud to 9600 baud. (Speed in bauds is the number of signal elements or digits transmitted per second). Digital machines therefore can send single-page documents in as few as 12 seconds!

Some fax terminals operate in a real-time mode, others in store and forward. Real time models immediately send the information fed into the source machine to the intended receiver. Store-and-forward terminals read the information into the machine's memory and transmit it at a later time specified by the sender. Newer terminals have special interfaces enabling them to communicate with computers, word processors, and telex machines. Others are strictly stand-alone units designed to work independently. In any event, facsimile machines have come a long way since the late 1970s when the units were slow, copy quality was poor, and an operator needed to be present at both ends. Information transmission via today's machines is automatic. The sender simply dials the telephone number of another machine and presses a button. As long as the receiver's machine is activated, he or she need not be present to acquire the document sent.

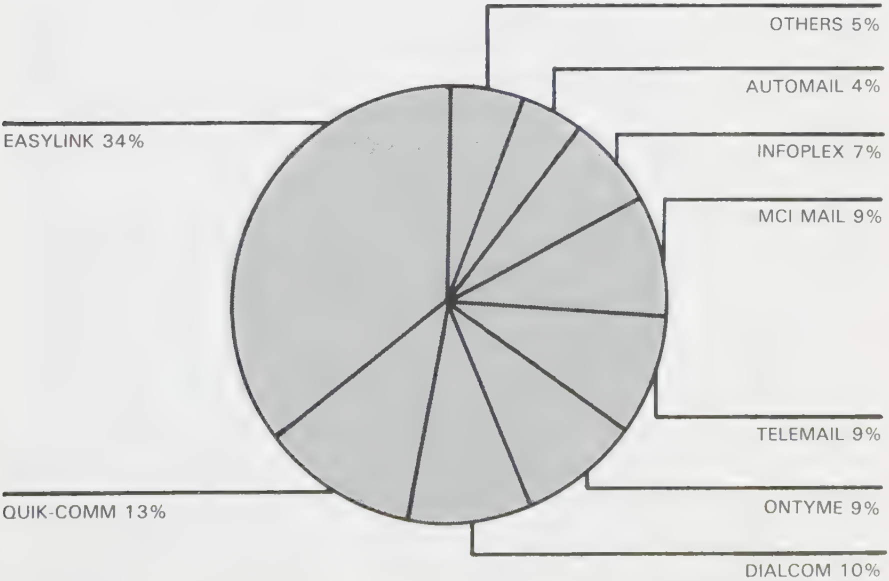
On an international scale, facsimile is growing in response to the advent of world-wide direct distance dialing and the repeal of a ban on transmitting data over international telephone lines. Previously, users were forced to rely on telex where the information had to be re-keyed and it was not possible to send an assortment of graphic images.

Without question, facsimile transmission will remain an important component of tomorrow's communication networks. Like cellular telephones, the use of facsimile permits people to conduct business without being confined to their offices. It is a cost-justified form of electronic mail. Fax machines may even begin to appear in the private household over the next several years. Facsimile is here to stay—it is a progressive technology that seems to benefit anyone who has an urgent need to communicate a visual message to someone in a remote location.

ELECTRONIC NETWORKING

Another trendy development in the field of telecommunications has come into its own among millions of personal computer users. The label that has been ascribed to a series of user options is **electronic networking.** The personal computer coupled with electronic networking is also changing the way people communicate with each other in today's world.

One of the most commonly used networking methods bears the name **electronic mail** where messages are sent from one person to another through some sort of computer channel. Public E-mail services are available through a number of vendors, Figure 4.6. Electronic mail can be sent through bulletin boards, utilities, and some telephone services. Local bulletin boards and the large utilities commonly provide "mailboxes" for their users. Correspondents may simply address a message to you and the message is there when you sign on to the system. Generally speaking, when you sign on, there is a note that will inform you that you have mail and ask if you want to read it immediately.



1985: 11.7 MILLION MESSAGES SENT

Figure 4.6 Public electronic mail services vendor market shares in 1985. (International Data Corp.)

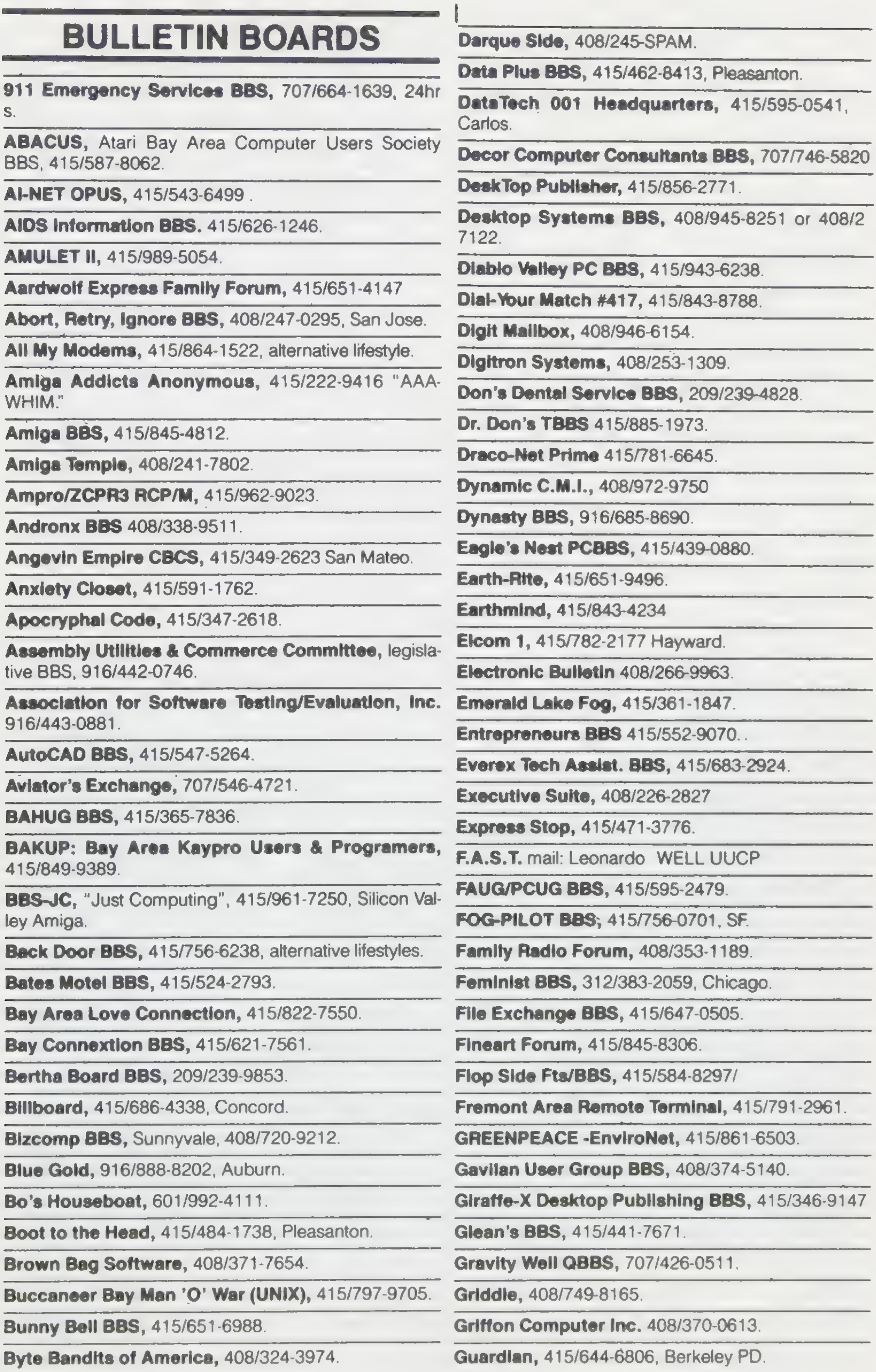
Local Bulletin Boards

Electronic bulletin boards, also known as **hobby boards** or simply BBSs (for bulletin board systems), are presently operating all over the world. These computer networks are accessible by phone to anyone with a computer and a modem. Each BBS is actually a community in itself regardless of the geographic location of its callers. The personality of the bulletin board is often a reflection of its system operator (sysop) who is the dedicated individual responsible for maintaining the system. Common functions of the boards include: 1) sending and receiving public or private messages, 2) transferring text or program files, and 3) posting general interest bulletins. Although bulletin board users post all sorts of messages detailing personal inquiries regarding everything from area restaurants to dog kennels, the overwhelmingly favorite topics on most boards are: microcomputer hardware information, microcomputer software availability and/or user problems, and microcomputer communications.

One type of board that is primarily computer-oriented is the **pirate board.** These bulletin boards are usually engaged in illegal activities and therefore come and go and move around a lot. This sounds like the proverbial floating crap games on the waterfront! The purpose of these boards is to help people obtain free or pirated copies of copyrighted software and gain access to computers that are otherwise inaccessible.

Phone phreaking is another common amusement on pirate boards. This activity involves charging long distance phone calls to someone else's phone number or to another illegally accessed account. Phreaking includes such techniques as breaking into corporate switchboards through phone lines to make conference calls and using stolen identification numbers for Sprint, MCI, and other toll services. Long-distance companies viewed the problem as being quite serious and ultimately formed the Communications Fraud Control Association. This group was assembled to allow its members to exchange information about illegal bulletin boards and lobby for stronger legislation. Using a stolen code or card number is clearly illegal, but is it a crime to post those numbers on a bulletin board? Since some attorneys view this activity as a First Amendment right, answers remain cloudy. Nevertheless, many hackers have begun to feel the heat of the law enforcement sector. Some recognize the need to weigh the thrills of using their high tech skills to challenge the system against the possibility of earning a criminal record.

Most computer bulletin boards are totally legitimate. Government agencies run bulletin boards. For example, the National Aeronautics and Space Administration operates one called Get-Away Special Users' Net. GAS-NET invites ideas from anyone who wishes to submit a proposal concerning small, self-contained experiments to be conducted on future space shuttle flights. Other bulletin boards are purely commercial and some are designed to play high-tech matchmaker. One characteristic that is common to almost all bulletin boards is that they list the telephone numbers of other boards, Figure 4.7. By getting one phone number, users gain instant access to boards all over the country!



BULLETIN BOARDS

911 Emergency Services BBS, 707/664-1639, 24hrs.

ABACUS, Atari Bay Area Computer Users Society BBS, 415/587-8062.

AI-NET OPUS, 415/543-6499 .

AIDS Information BBS. 415/626-1246.

AMULET II, 415/989-5054.

Aardwolf Express Family Forum, 415/651-4147

Abort, Retry, Ignore BBS, 408/247-0295, San Jose.

All My Modems, 415/864-1522, alternative lifestyle.

Amiga Addicts Anonymous, 415/222-9416 "AAA-WHIM."

Amiga BBS, 415/845-4812.

Amiga Temple, 408/241-7802.

Ampro/ZCPR3 RCP/M, 415/962-9023.

Andronx BBS 408/338-9511.

Angevin Empire CBCS, 415/349-2623 San Mateo.

Anxiety Closet, 415/591-1762.

Apocryphal Code, 415/347-2618.

Assembly Utilities & Commerce Committee, legislative BBS, 916/442-0746.

Association for Software Testing/Evaluation, Inc. 916/443-0881.

AutoCAD BBS, 415/547-5264.

Aviator's Exchange, 707/546-4721.

BAHUG BBS, 415/365-7836.

BAKUP: Bay Area Kaypro Users & Programers, 415/849-9389.

BBS-JC, "Just Computing", 415/961-7250, Silicon Valley Amiga.

Back Door BBS, 415/756-6238, alternative lifestyles.

Bates Motel BBS, 415/524-2793.

Bay Area Love Connection, 415/822-7550.

Bay Connextion BBS, 415/621-7561.

Bertha Board BBS, 209/239-9853.

Billboard, 415/686-4338, Concord.

Bizcomp BBS, Sunnyvale, 408/720-9212.

Blue Gold, 916/888-8202, Auburn.

Bo's Houseboat, 601/992-4111.

Boot to the Head, 415/484-1738, Pleasanton.

Brown Bag Software, 408/371-7654.

Buccaneer Bay Man 'O' War (UNIX), 415/797-9705.

Bunny Bell BBS, 415/651-6988.

Byte Bandits of America, 408/324-3974.

Darque Side, 408/245-SPAM.

Data Plus BBS, 415/462-8413, Pleasanton.

DataTech 001 Headquarters, 415/595-0541, Carlos.

Decor Computer Consultants BBS, 707/746-5820

DeskTop Publisher, 415/856-2771.

Desktop Systems BBS, 408/945-8251 or 408/2 7122.

Diablo Valley PC BBS, 415/943-6238.

Dial-Your Match #417, 415/843-8788.

Digit Mailbox, 408/946-6154.

Digitron Systems, 408/253-1309.

Don's Dental Service BBS, 209/239-4828.

Dr. Don's TBBS 415/885-1973.

Draco-Net Prime 415/781-6645.

Dynamic C.M.I., 408/972-9750

Dynasty BBS, 916/685-8690.

Eagle's Nest PCBBS, 415/439-0880.

Earth-Rite, 415/651-9496.

Earthmind, 415/843-4234

Elcom 1, 415/782-2177 Hayward.

Electronic Bulletin 408/266-9963.

Emerald Lake Fog, 415/361-1847.

Entrepreneurs BBS 415/552-9070. .

Everex Tech Assist. BBS, 415/683-2924.

Executive Suite, 408/226-2827

Express Stop, 415/471-3776.

F.A.S.T. mail: Leonardo WELL UUCP

FAUG/PCUG BBS, 415/595-2479.

FOG-PILOT BBS, 415/756-0701, SF.

Family Radio Forum, 408/353-1189.

Feminist BBS, 312/383-2059, Chicago.

File Exchange BBS, 415/647-0505.

Fineart Forum, 415/845-8306.

Flop Side Fts/BBS, 415/584-8297/

Fremont Area Remote Terminal, 415/791-2961.

GREENPEACE -EnviroNet, 415/861-6503.

Gavilan User Group BBS, 408/374-5140.

Giraffe-X Desktop Publishing BBS, 415/346-9147

Glean's BBS, 415/441-7671.

Gravity Well QBBS, 707/426-0511.

Griddle, 408/749-8165.

Griffon Computer Inc. 408/370-0613.

Guardian, 415/644-6806, Berkeley PD.

Figure 4.7 Typical list of Bulletin Board phone numbers.

Information Utilities

If local bulletin boards whet the user's appetite for communicating electronically, the next logical step involves accessing large information utilities. The two largest information utilities in the United States are COMPUSERVE in Columbus, Ohio and THE SOURCE in McLean, Virginia. Both require a user's fee and are easily used for networking. Information utilities are also called videotex. **Videotex** is the term presently used generically to describe low-cost, easy-to-use, computerized information systems that are aimed at the mass market.

Videotex applications can be classified in five general categories: (1) retrieval [news, sports, weather, travel schedules, stock market reports]; (2) computing [computer-assisted instruction, management information services, income tax tools]; (3) transactional [teleshopping, home banking]; (4) messaging [bulletin boards]; and (5) downloading [transmitting tele-software programs to intelligent terminals]. These types of videotex services may be transmitted to the receiver's terminal by coaxial cable, fiberoptic cable, telephone line, radio, satellite or microwave. Videotex data, usually a combination of text and graphics, can be displayed on television sets, microcomputer terminals and thermal or impact printers. See Figure 4.8.

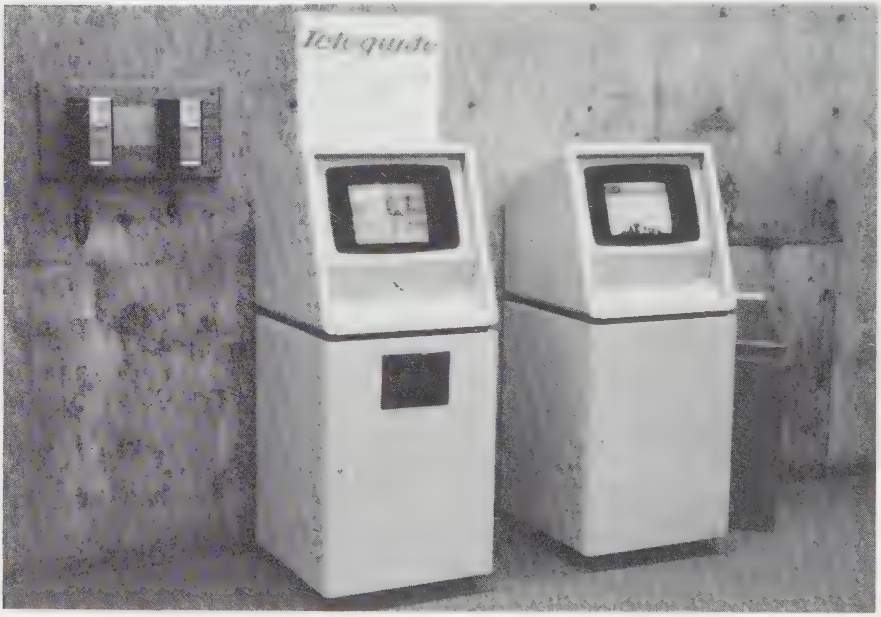


Figure 4.8 Videotex terminals can be found in stores, bus stations, airports, college campuses, etc. Shown here are the type of videotex terminals currently in use on the San Jose State University campus in San Jose, CA. Users are able to quickly "retrieve" information regarding the locations of buildings on campus, campus events, news, weather, films, and so forth. (Michael Dafferner)

Fully interactive videotex has been given the label **Viewdata.** In this mode, users' requests for services or information are actually sent to, received by, and acted upon by the system's mainframe computer. In the United States, the terms videotex and videotext (note the final "t") have become synonymous with viewdata. Broadcast videotex is called **Teletext.** These computerized information and entertainment systems use a normal television signal to distribute the data to television sets or monitors. Teletext users can select the information or service to be received, but this involves only a one-way communication link. Stated differently, teletext is pseudo-interactive. A final version of videotex is known as **open-channel teletext.** One widely recognized application of this technology is called closed captioning, which has become an important communication aid for deaf persons. Other uses include cable television information channels, open captioning and airline arrival/departure displays.

The role of videotex as a communications tool is growing rapidly throughout the world. As with any other communications technology breakthrough, issues regarding its regulation and use in society have surfaced. Skeptics have identified some of their more serious concerns in essays discussing: government regulations, government-approved tariffs, system ownership, transborder data flow, privacy and security of information, participatory democracy, and teleservices. Videotex will eventually change the ordinary television set from a passive entertainment tool to an interactive device.

The social repercussions stemming from the proliferation of television-based services are still difficult to project. We may find ourselves using a new descriptive term to refer to persons who prefer videotex to either human or social interaction—any ideas?! The concept of an electronic cottage may degenerate into total electronic seclusion. Future issues to be addressed include insuring personal privacy and encouraging the videotex industry to reach out to all segments of the population—not just to those who can afford it.

CORPORATE TELECONFERENCING

Most of you at one time or another have probably seen the television advertisements that tout the importance of "keeping in touch by telephone"—especially in the competitive, breakneck pace business world. The intent of those ads was to exemplify communication links as the key to success among Fortune 500 companies. Behind those meaningful telephone conversations however, there were most likely numerous face-to-face luncheon meetings called in order to keep the wheels turning and put out fires before they got out of hand. Teleconferencing is the communications technology that is designed as an alternative to these face-to-face meetings. To complement this newest business strategy, the "telecommunications manager" job title was reformulated to reflect changes in the technology.

The basic philosophy of teleconferencing has focused on moving electrons rather than people. Advocates of this type of electronic meeting credit teleconferencing for reduced business travel costs and much improved communications. It is estimated that nearly 80 percent of all business meetings that require travel are intercompany conferences between or among people who already know each other. Electronic meetings can replace the necessity of being physically together. Refer to Figure 4.9.

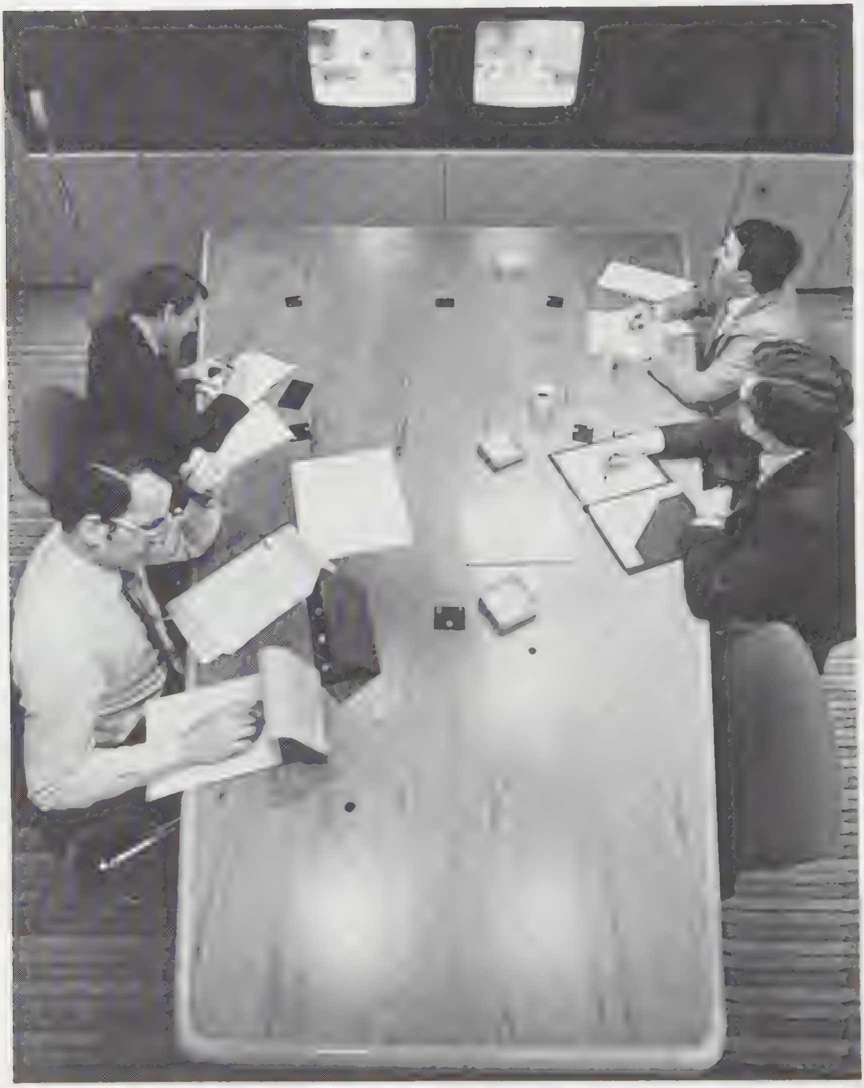


Figure 4.9 Aetna Life & Casualty Company was one of the first large scale users of videoconferencing Corporate executives are shown here conducting a meeting between two sites using full-motion video conferencing technology in Aetna's dedicated videoconferencing studios.

Teleconferencing also allows managers to draw on experts working in various locations to answer specific technical questions that may come up during a meeting. Transmission costs for these teleconferences are still rather high, but this fact alone seems to motivate conferees to arrive at their meetings more well prepared. Knowing that their satellite air time is limited, people tend to get right to the point without rambling on for lengthy periods.

TELECONFERENCING SYSTEMS

A rigid definition of teleconferencing is difficult to provide since there are numerous technologies converging and emerging in this field on a regular basis. **Teleconferencing** is the term most commonly associated with some sort of interactive, group communication that takes place through any electronic medium. One important distinction among the various forms of teleconferencing is the time element.

The conference is **synchronous** or "real time" whenever all participants are present simultaneously, regardless of their location or time zone. Currently, most audio and video conferences are synchronous. If participants have the option of checking into the conference at will, it is considered **asynchronous** or a "store and forward" conference. Utilization of voice message systems approaches the concept of asynchronous audio conferencing. Electronic mail systems have introduced the store and forward text communication channel.

Video teleconferencing systems offering "real time" meeting possibilities are further classified into several subgroups.

Full-Motion Video Conferencing. This type of system permits the transmittal of full-motion images of people between two or more sites. The transmissions can be either one-way or two-way sent over broadband or compressed video links. See Figure 4.10

Fiberoptic cable has been identified as the transmission medium of the future for video conferencing. Satellite communications and standard telephone lines are still the most commonly used means for transmitting signals. Significant technological improvements have been made in codecs (coder-decoders). These are the computers that compress and digitize video signals. Signal compression has a tendency to reduce image quality by comparison to analog video signals. The resultant images still appear to be satisfactory for corporate video conferencing.

Many corporations get started in video conferencing using what is called full-motion broadcast video. This is an analog technology that uses a direct broadcast satellite (DBS). It provides one-way video and two-way audio. The video portion is transmitted by satellite while the audio uses standard telephone lines. Also known as ad hoc video conferencing, this communication option is basically closed circuit television. It requires not only dedicated teleconferencing rooms but also earth stations at each site.

Freeze-Frame Video Conferencing. This format is based on the transmittal of still images of things like documents, maps, photographs, charts and graphs.

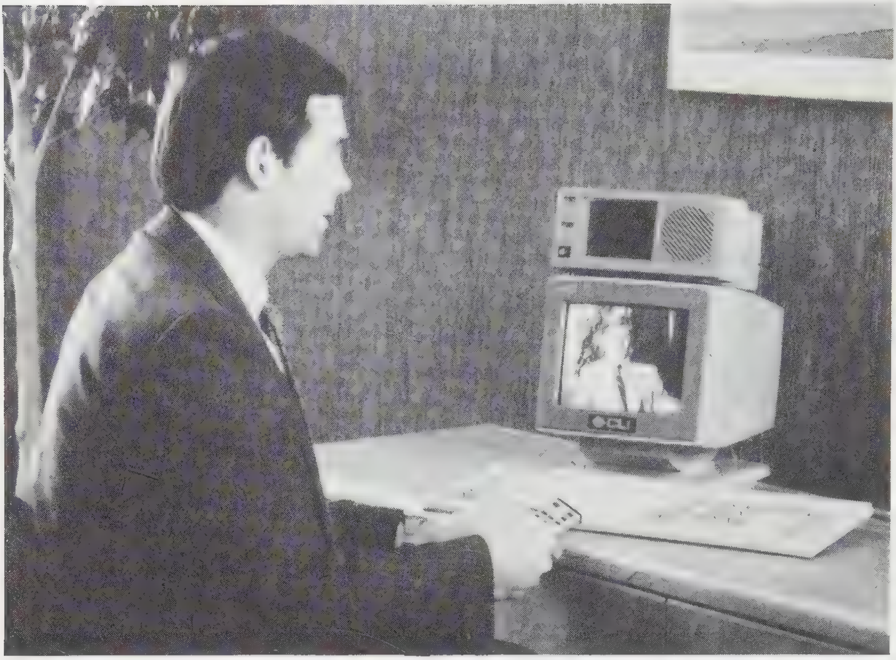


Figure 4.10 The Rembrandt Desktop Videostation from Compression Labs is the first personal computer-based system to allow full-motion, full-color videoconferencing between local or remote stations. Individuals or small groups can hold face-to-face meetings from a personal computer in the privacy and convenience of their own offices. (Compression Labs Inc.)

Transmissions are sent between two or more sites over lowband communications links (dial-up telephone lines). Freeze-frame video conferencing focuses not on the people but on the problem. This technology allows still images to be transmitted to multiple sites over standard dial-up telephone lines. This accounts for a substantial reduction in cost when compared with full-motion video teleconferencing.

This form of communication link is most useful when the key element of the meetings is the evaluation and review of documents. Full-motion video is not essential unless it is imperative for viewers at both ends to see each other face-to-face. In some cases, people need to be able to respond to body language messages in addition to simple audio statements.

Videographics Teleconferencing. System users have the ability to add interactive foreground-annotation to any background image. Images can be generated by a full-motion, freeze-frame or computer teleconferencing system. This technology can also be used without a background image and act as an **electronic blackboard.** In this mode, executives can use chalk to write on the electronic blackboard that is linked to a cathode ray tube by the phone lines. Conferees at the receiving end can see the results on their television screens.

An interactive graphics display allows its users to reach directly into a dynamic video image and register directly on it. They can then draw, write, and annotate over the background image. The resultant "set" of foreground and background images can be transmitted to multiple remote locations. When used in a major broadcast environment, for example by a sportscaster during a football game, this technology earned the nickname "CBS Chalkboard."

Computer conferencing technology is a variation of video teleconferencing. It allows companies to edit documents at different sites and send the updated information through modems. Furthermore, video capture boards enable users to take a picture of a graph or document with a television camera that is captured on the PC screen. The PC board can next digitize the picture and transmit it over telephone lines. Some models can store up to 100 color images on a floppy disk. In light of these developments, teleconferencing seems to be getting closer and closer to the desk top. Video telephones may actually be a very near reality.

A FEW CORPORATE SUCCESS STORIES

Available statistics at the time of this writing revealed that teleconferencing was one of the fastest growing segments of the telecommunications industry. Teleconferencing experts continue to project growth and expansion for this industry. A few of the more visible corporations that are currently making use of this technology are summarized below. Note that, in each case, the level of technology selected was effectively matched with the users' technical needs and business expectations.

Bank of America: Since the late 1960s, Bank of America executives in San Francisco and Los Angeles have been meeting regularly without subjecting themselves to the pressure of commuter flights. They use tastefully appointed conference rooms to conduct their business over a high quality audio conferencing system.

IBM: This corporation has had its own in-house system for still video conferencing since the mid-1970s. Their system displays snapshot-like images on television monitors that are accompanied by audio conversations. Since most of the participants have technical backgrounds, they find the system useful for discussions that concentrate on charts, diagrams, viewgraphs and engineering drawings.

Procter & Gamble: Employees of this firm have had access to their own computer-based conferencing system since the late 1970s. The system is called CONFER and it can be used directly via personal computer terminals or indirectly through secretaries or the company's mail system. Text-based teleconferences are carried out over periods of weeks or months. Managers from most divisions in the company keep abreast of changes and remain involved.

Aetna Life and Casualty Company: Since the early 1980s, this corporation has been using full-motion video conferencing to link its downtown offices to its suburban locations. It is a full-color system that requires no training to use and operate. Data processing personnel use the system quite regularly and Aetna is continuing to project expansion for the system to sites in other areas of the country. See Figure 4.11.

Hewlett-Packard: Senior executives employed with this multinational firm have been using live video presentations to introduce new products to its national sales force since the early 1980s. Participants gather at their respective local offices to receive product information from the people who actually developed the item. Inquiries can be made via an audio call-back channel.

Boeing Corporation: Corporate officials here, in the early 1980s, reported that video conferencing allowed them to bring their 757 aircraft to market several weeks ahead of schedule with substantial cost savings. The greatest saving was derived from the ability of engineers at remote locations to catch problems that might have otherwise gone unnoticed. Boeing engineers rely on audio channels coupled with still photographs of drawings and charts. They alternately use full-motion video for special situations such as conducting interviews with test pilots immediately after test flights.

POTENTIAL EFFECTS OF TELECONFERENCING

Even though statistical support for their claims is still somewhat inconclusive, teleconferencing enthusiasts continue to use travel substitution as the most common justification for corporations to invest in the technology. Higher level

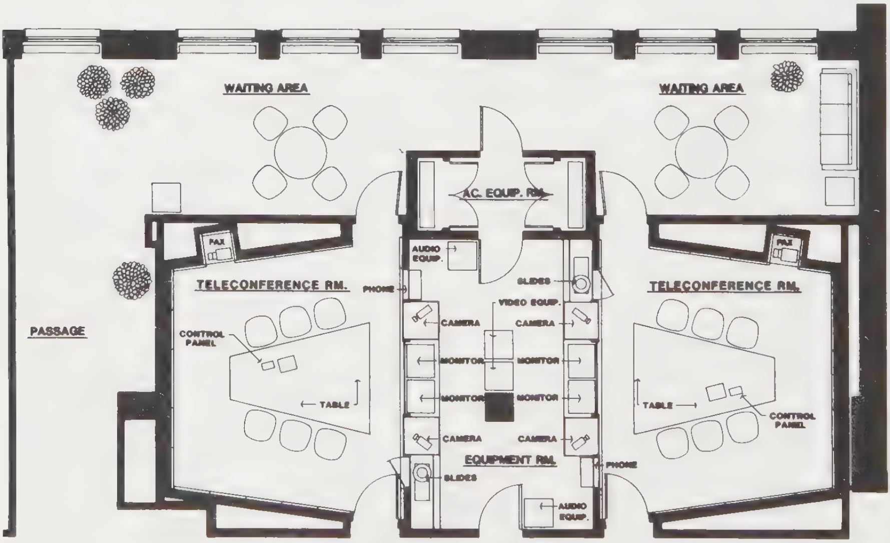

WAITING AREA
WAITING AREA
A.C. EQUIP. RM.
AUDIO EQUIP.
FAX
FAX
TELECONFERENCE RM.
TELECONFERENCE RM.
PHONE
SLIDES
VIDEO EQUIP.
PASSAGE
CONTROL PANEL
CAMERA
CAMERA
MONITOR
MONITOR
MONITOR
MONITOR
TABLE
TABLE
CONTROL PANEL
CAMERA
CAMERA
EQUIPMENT RM.
PHONE
SLIDES
AUDIO EQUIP.

Figure 4.11 Located in Hartford, CT, this illustration depicts the layout for a pair of rooms in Aetna Life & Casualty's teleconferencing facility. (Courtesy Aetna Life & Casualty, Hartford, CT)

executives are generally attracted by this claim. It is no secret that the cost of moving people from place to place is escalating, as is the discomfort of the people being moved. Although some employees genuinely enjoy traveling, most find it very draining. Interestingly enough, teleconferencing has not yet proven to be a direct substitute for travel. There are a lot of other factors at stake for the company that decides to invest in a teleconferencing facility.

If teleconferencing is to be effective, it must be reviewed critically for what it is—a branch in the family of office systems technologies. Teleconferencing should be viewed as a business communications support system rather than as a rigid replacement for face-to-face meetings. Not all organizations have the same potential for success as those corporations that were highlighted above. This is not necessarily due to a lack of technical competency or even insufficient investment capital. It may very well be that this technology does not address a specific task or area of need within each and every corporate setting.

When deciding to implement teleconferencing, several aspects of the technology should be evaluated. Do the potential cost advantages outweigh the possible negative side effects that may develop over time? Take a moment to place yourself in the position of the CEO who is attempting to make this type of commitment to a new form of business communication—consider the following:

Cost Advantages —Teleconferencing Might:

☐ Reduce travel expenses.
☐ Reduce unproductive time for persons doing the traveling as well as their inevitable travel fatigue.
☐ Reduce mistakes made due to the fact that the critical person was not at the meeting as scheduled.
☐ Shorten the normal business cycle and facilitate more efficient decision making.
☐ Reduce equipment down time when the most skillful repair person is at another site.
☐ Reduce the effects of unforeseen interruptions due to weather, fuel shortages, or political upheavals.

On the other hand, there are several

Negative Effects—Teleconferencing Could:

☐ Increase the amount of unproductive time spent in meetings that are easily arranged but unnecessary.
☐ Decrease freedom of operation for the remote field sites due to an excessive amount of managerial control.
☐ Lower employee morale because of decreased personal contact.
☐ Encourage people to become overspecialized and narrow-minded.
☐ Foster an overdependence on technology that could easily fail as a result of equipment limitations or even sabotage.

Notice that the key words in both of these lists are “might” and “could.” No decision regarding technology comes with a menu of guaranteed outcomes.

Teleconferencing is a technology that can bring many benefits to the economy as a whole and could potentially serve the political sector as well. One effect that teleconferencing technology is having on society is reviewed in the next segment of this chapter.

EMERGENCE OF TELECOMMUTING AS AN EMPLOYMENT MODE

Alvin Toffler authored the best selling book entitled *The Third Wave* and coined the term **electronic cottage** to describe a trend that was, and still is, developing in our society. A convergence of powerful technologies has begun to reshape the way people perform their employment duties. AT&T recently estimated that some 11 million individuals including writers, consultants, real estate agents, music teachers and an assortment of other professionals were working out of their homes. Estimates of the number of them who were using a computer and a telephone line to "commute" to their office ranged from 20,000 to 1 million. These employees are sometimes called "invisible workers" but are more commonly referred to as **telecommuters**. The word telecommuting itself was first coined at the University of Southern California's Center for Futures Research in the early 1970s. (Oddly enough, it coincided with the Arab oil embargo.)

The spread of home computers has served to accelerate this trend as a large number of companies initiated general telecommuting programs for their employees. More importantly, the links between remote locations and corporate offices for computers, facsimile transmitters and other communications equipment are becoming more sophisticated. As this happens, it is likely that even more companies will shift some of their employees' work to the home. Some observers project that by the turn of the century as much as 20 percent of the entire population could be involved with computerized home work.

PERCEIVED BENEFITS

There are some proponents of telecommuting who suggest that consumers will be the ultimate beneficiaries as the trend toward electronic home work continues to emerge. Companies' direct expenses will be lower. Established firms will face greater competition as entrepreneurs take advantage of technical developments and hire on workers who had not previously been part of the traditional work force. This may lead ultimately to lower consumer costs for established goods and services.

One of the most significant economic benefits for companies that are considering launching a telecommuting program is the potential for saving on current or additional office space, building maintenance, and computer time. Unlike the costs associated with the computer electronics industry, construction prices continue to climb. When a company doubles its work force in a short period of time, the cost of building expansion may be prohibitive. Fixed expenses can also be cut by utilizing computers during off-peak hours in the evening or on weekends.

Telecommuting programs are also a mechanism through which organizations can recruit and retain valuable employees. These programs can also cut relocation costs for both new and veteran employees. Companies can eliminate the fees for moving its personnel to housing that is within commuting distance by allowing these individuals to work from their homes. Telecommuting workers may then be asked to commute only occasionally to either the main office or a nearby satellite office.

Statistical reports reveal that productivity decreases among telecommuters for a brief period of time. Following the adjustment period however, productivity increases as much as 40 per cent. Telecommuters who sincerely enjoy working at home tend to work harder and longer than their office-restricted counterparts. One of the most prevalent productivity nightmares is the winter blizzard. If the office does not have to close down completely, it is probable that the few employees who do manage to show up to work will spend most of the day worrying about the trip home instead of getting any useful work done. The employees who never left home to start with are easily going to be more productive under these circumstances.

In short, telecommuting promises benefits for all concerned. It yields lower costs for businesses, more freedom for workers, a fuller family life for mothers and fathers, and employment for disabled persons. Telecommuting also appears to increase the range of services and products available to consumers and lowers prices along the way.

POTENTIAL DRAWBACKS

Before you close the textbook to start dreaming about the luxurious life of the telecommuter, it is necessary to review some of the not-so-wonderful aspects of telecommuting. From the corporate perspective, one of the most frequent excuses used in opposition to telecommuting programs references the loss of managerial control. Some executives believe that it is impossible to manage persons that they never see. Overcoming this “out of sight” prejudice may take more time for some than others. Ironically enough, managers who perceive that their employees who arrive at the office on time and look busy at their desks may be the brunt of a “snow-job” in some cases. The counter to their argument lies in the fact that telecommuters must be measured by their output and have fewer opportunities to “snow the boss” so to speak.

From the employees’ viewpoint, the “out of sight/out of mind” syndrome may be more serious. They may be forced to deal with the possibility that they will be overlooked when it comes to such things as promotions, new projects and raises. Prime decision makers within organizations who give promotions tend to work during conventional daytime hours. Those workers who work outside of the nine-to-five routine have always been at a disadvantage. Since it is frequently the casual interactions that take place on the job site that open doors for career advancement, the invisible employee may remain on the outside looking in.

Many persons look to their work place as a respite from domestic chores and responsibilities. If the home becomes the work place, these persons may experience a sense of imprisonment and isolation. Adult workers often need a chance to interact with colleagues for socio-psychological reasons. Face-to-face meetings also encourage workers to remain involved with the organization and keep abreast of technological changes that may be pending.

More importantly, working at home requires a considerable amount of self discipline coupled with tremendous concentration. Although the office environment has its share of interruptions, a person's home is full of distractions that may be difficult to avoid. Unsuccessful telecommuters report that they have gained weight, learned how to procrastinate in the garden and gotten hooked on a daytime soap opera. On the opposing side of these stories is the tale of the man who insisted on dressing in a three piece business suit each morning before walking down the hall to his den to begin the work day with a tape of the sounds of his former office! Other family members may not be able to adapt to the ever-changing roles the telecommuter is forced to play when the home is where the job is. This may be regarded as the "daddy doesn't work anymore" syndrome.

Finally, the issue of security eventually comes to the mind of corporate executive officers who are responsible for managing large amounts of data. Is it wise to allow sensitive corporate data out of the office? Information becomes vulnerable as it is conveyed electronically via a modem or on a disk or tape. Papers that are shipped to and from home workers can easily be lost or stolen. Who is liable for the security of the information once it leaves the corporate office—the CEO or the telecommuter?

EMPLOYEE SELECTION CRITERIA

Some telecommuting advocates say that the question is not who should be allowed to work at home, but who should be forced to work in the office! This statement may be somewhat premature in light of the above concerns. Other proponents indicate that the key to initiating a successful telecommuting program is the selection process itself. The company, rather than the employee, should set the selection criteria. Once these criteria have been established and potential candidates have been identified, the process should then become one of voluntary self-selection. In other words, approved employees should have the option of either accepting or rejecting the offer.

Some of the numerous personnel selection guidelines that have been used by corporations who have been satisfied with their telecommuting programs are summarized below. If you ever find yourself in the position to make this decision, perhaps these criteria will be insightful.

- ☐ Employees whose work is dependent on direct interaction with customers who visit corporate offices can not work effectively at home.
- ☐ Employees who are regularly involved in team projects and those whose work is regularly dependent on interaction with their colleagues are usually

eliminated from consideration. Some companies, however, allow team employees to meet at specified times at the office or at the home of one of the members. The trick is to avoid wasting time playing "telephone tag."

☐ Some companies have had success in hiring employees specifically to work at home. Most recommend that telecommuters be selected from personnel who have been with the company for some time and understand how it operates.

☐ The psychological makeup of the employee is also crucial. Not everyone is suited for electronic home work. Telecommuters must be intrinsically motivated individuals who can work well without immediate supervision. It is also prudent to eliminate those persons who obviously place a high priority on the social relationships fostered in the office.

☐ Successful companies do not offer the telecommuting option as an employee benefit. It is not a reward. It is simply another way of getting the job done.

☐ Successful telecommuting requires that telecommuters return to the office periodically. As a rule, most effective programs tend to require their telecommuters to return to the main or area office at least one day per week to "plug back into" the daily office routine.

IMPACT OF ELECTRONIC RECORD KEEPING ON PRIVACY

Years ago, in small towns across the nation, community residents often made it their business to be in tune with what everyone else was up to. Although this "meddling feature" came to be accepted as a way of life, it existed long before we entered the so-called "information age." People did not concern themselves too much with their individual rights to privacy. More often than not, they simply accepted the fact, that sooner or later, their neighbors would be wise to their daily activities as well as their deepest family secrets. With our current electronic record keeping systems and numerous communications networks in operation, these persons have a lot more to worry about than their busybody neighbors!

Many of the technological developments reviewed in this chapter have a direct effect on the extent to which personal information is considered public or private. Advancements in electronic mail, digital telephony, teleconferencing, and other forms of computer to computer communications have raised serious questions about the protection of privacy. The exponential growth in the collection, storage and communication of personal data seems to have been accompanied by an increased potential for abuse and misuse. Satellite technology has introduced an international dimension into the dilemma. Personal information can be indiscriminately exchanged back and forth around the globe.

Numerous case studies and popular editorials have been published on the topic of personal privacy. Others address the issue of legislation, or the lack of it, that is designed to protect our individual rights to privacy. For the most part, these writings are generously sprinkled with horror stories of persons who have been refused credit, insurance, employment, or welfare assistance.

What makes these personal accounts horrifying is that the actions taken were usually predicated on incorrect, outdated, or deliberately manipulated data.

PUBLIC POLICY

In 1974, the United States Congress passed the Privacy Act to address the tension between individuals' interest in their personal information and the Federal Government's collection and use of that information. Privacy is a value that has always been regarded as fundamental, but its meaning has remained obscure. The definition that served as the basis for this legislation read something like this:

> Privacy is the claim of individuals, groups or institutions to determine for themselves when, how and to what extent information about them is communicated to others.

Following its passage, the Office of Management and Budget (OMB) was given the responsibility for overseeing agency implementation of the act. Specifically, this legislation prohibited government agencies from swapping information about American citizens without first obtaining their permission. The Privacy Act also said that the government could not collect information for one reason and later use it for something else. At the time this benchmark legislation was debated and finally enacted, the majority of record systems being used in Federal agencies were manual. Computers were only utilized to store and retrieve data. They were not used to manipulate or exchange information between and/or among different files.

In less than two decades, at least two generations of information/communications technology have become available to these agencies. Most agencies presently collect, use, store, exchange and manipulate our individual records in electronic form. The widespread use of microcomputers has drastically increased the number of access points to personal record systems. Many Federal benefit programs use computer matching techniques and computer-assisted front-end verification systems on a routine basis. These technological advances have most certainly opened new avenues for improving the efficiency of record keeping. At the same time, the opportunities for inappropriate, unauthorized, or illegal access to and use of personal information have expanded. The Office of Technology Assessment (OTA) recently submitted a study concerning individual privacy and concluded:

> Federal use of new electronic technologies in processing personal information has eroded the protections of the Privacy Act of 1974. Many of the electronic record applications being used by Federal agencies are not explicitly covered by the act or by subsequent OMB guidelines. The rights and remedies available to the individual, as well as agency responsibilities for handling personal information are not clear . . . . agencies have little incentive to consider privacy concerns when deciding to establish or expand the use of personal record systems.[1]

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[1] *Electronic Record Systems and Individual Privacy.* U.S. Congress. Office of Technology Assessment. Washington, D.C., 1986. (GPO Stock No. 052-003-01038-1)

Privacy continues to be a significant and enduring value held by the American public. It is apparent through a review of several opinion polls and numerous casual interviews that many persons believe that computer electronics and communications technologies exemplify pervasive threats to their individual privacy. General concern regarding the lack of adequate safeguards to protect personal records has grown over the past several years. It seems that a large percentage of United States citizens see the need for new and revised laws that will govern how personal information records can be used by organizations that have computer files. The legal system is presently lagging too far behind the technological capabilities related to this issue. Simply stated, there is increasing public support for additional government action to protect privacy in this country.

CONDITIONS IN THE PRIVATE SECTOR

While privacy policy for the public sector remains inadequate, that for the private sector on a national level is largely nonexistent. Personal information in the private sector can be collected, stored and transmitted with very few governmental restrictions. Key areas of information acquired include consumer credit, banking, insurance, employment, medical care and education. Now that some grocery stores and gasoline stations allow their customers to use their bank cards to make purchases, this list will undoubtedly expand to include our eating habits and automobile usage as well. The era of national computer privacy regulation may not be imminent (ready to take place) yet. But, persons who are living in the throes (painful struggle) of computerized communication networks may actually find themselves wishing for this type of regulation!

Computer blacklists have recently become a burgeoning growth industry in the field of information technology. A sophisticated form of computerized credit record service, they also represent another electronic assault on individual privacy. Though still somewhat young, the computer-blacklist industry already has its giants. For example, TRW Information Services in Orange, California and Equifax Inc. in Atlanta, Georgia have long relied on huge banks of mainframe computers to conduct their business. These credit bureaus provide consumer credit records for banks, department stores, finance companies and employers. On an average working day, TRW's machines process some 250,000 requests for information. In doing so, they cull through a massive data base that contains detailed records of the bill-payment habits of over 100 million people.

In many states across the country, "bad-risk tenant" lists have contributed to the growth of this industry. Denver-based RentCheck boasts a coast-to-coast information network. Subscribers to this service control over 2.5 million rental units, which accounted for nearly 10 per cent of the total U.S. rental housing supply in the mid-1980s. Chicago-based Docketsearch Network Corporation has compiled the names of over 2 million Americans who have filed medical-malpractice, product-liability, or personal injury lawsuits. Doctors who subscribe to this service can call a toll-free number, give a prospective patient's name, and find out whether or not that person likes to file suits, all in less than 30 seconds. Docketsearch has indicated its plans to expand its listings in the near future. They want to incorporate records of bankruptcies, tax liens, and worker's compensation claims into their data base.

It has become obvious that any persons who own personal computers and have access to public documents can set up their own miniature private investigation firms. Just imagine the potentially damaging information that could be mishandled as dozens of these "front room" data services begin to set up shop. Regulations governing these novel private computer blacklists are inconsistent and often difficult to interpret.

Some states are responding to the perceived crisis with protective legislation. In some areas, legislation that would place an age limit on tenant data and restrict lawsuit records to those decided in the landlord's favor has been discussed. Purveyors of computer blacklists are certain to lobby against any bill that makes it harder for them to do business. Credit bureaus will argue that most people want the conveniences that computerized credit checks afford. We may actually have reached a point where it is necessary to give up a little bit of privacy in exchange for efficient service.

SUMMARY

Technology has changed the face of communications in our society. Telecommunications breakthroughs have transformed our views of each other and of the international community as a whole. Direct broadcast satellites enable us to be on the scenes of entertainment activities as well as terrorist uprisings instantly. Fiber optic technology holds many promises that have yet to be realized with reference to the quantity and type of information we can transmit through our telephone system.

If we truly live in age of an information explosion, perhaps the technologies associated with communications networks have converged to help us out. As the amount of information available to the general public has expanded, advancements in electronic record storage and retrieval have followed. Rather than be fearful of our inability to keep up with the rampant pace of change in the telecommunications industry, we should systematically accept these developments for what they are—a series of mechanisms and devices that empower us to communicate with one another in a whole new array of different ways.

This chapter dealt with several social issues related to the technological hardware associated with communications networks. Teleconferencing was examined as a corporate business communications strategy. The reality that workers may soon be given a telecommuting option to complete their job-related assignments was reviewed. Finally, individual citizens have begun to express their concerns regarding the need for government regulation to protect their privacy. The degree to which these issues will be resolved or widely adopted in the near future remains tentative.

DISCUSSION QUESTIONS

1. What is the primary purpose of installing a local area network (LAN) in a community? Give at least two examples of LANs with which you are familiar.
2. Identify and describe at least one advantage and one disadvantage to the use of fiberoptic cable over conventional coaxial cable.
3. Briefly, but systematically, explain what happens to the telephone call that you make from your home to a person who has a cellular telephone in his or her automobile. Your answer should indicate that you understand the technology behind the system.
4. What are some of the immediate advantages of teleconferencing in the corporate world? When might it be essential to invest in a full-motion video conferencing facility?
5. Besides the ones listed in the text, can you think of any other advantages or drawbacks to the practice of telecommuting in our society?
6. Describe some of the problems you might expect to encounter if you suddenly found out that your name had mistakenly been added to a computer blacklist. Be specific about the type of list on which your name has been placed. What steps would you take to have it removed from that list?

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Chapter 5

SPACE EXPLORATION

DATELINE

Montreux, Switzerland

During a recent Space Commerce conference, General Electric reiterated its interest in developing commercial space applications for the reentry vehicle concept it originally introduced years ago for military use. The company's Reentry Systems Operations Division is offering to engineer small vehicles that can be used for space-based processing, the return of samples from space stations, or as an emergency crew return system. Vehicles of this sort will be able to be orbited by expendable launchers, reusable systems or released from a future NASA/International space station. Recovery will be made with a ram-air gliding parachute.

General Electric has joined forces with an English firm called NIS to market the space recovery vehicle (SRV) concept in Europe. They are concentrating their efforts here since it is perceived that the European emphasis on the commercialization of space is greater than that of the United States. The size of the SRV can be scaled to meet user requirements; the largest one might weigh up to 70,000 pounds of which approximately 50% would be payload mass. Mission duration will range from a single Earth orbit to as long as several months. The University City Science Center in Philadelphia recently teamed up with General Electric and NIS to solidify its own plans to conduct an SRV launch in the near future . . . .

INTRODUCTION

When it comes to discussions about space exploration, many historians and political scientists alike seem to share a common sentiment. They tend to concur that no scientific venture has captured the fancy and emotional support of the American people as has the space program.

In early 1986, it quickly became apparent that the 25th mission of this nation's reusable spacecraft, the Shuttle, had attracted international attention. While its previous missions were devoted to sophisticated scientific research projects, this spacecraft was supposed to carry the first private citizen, a school teacher, into orbit. When the Challenger burst into flames less than two minutes after its liftoff, people around the world were forced to grasp the intensity of an unexpected tragedy. Stunned into silence, it is likely that many lost all faith in technology—even if just momentarily.

Following the crash, the National Aeronautics and Space Administration (NASA) was called upon to rethink its long range goals with regard to national space policy. In the wake of a disaster of this magnitude, there are never any easy choices or decisions to make. Some observers initially felt that the shuttle accident would bring an end to manned space flights for many years to come. Even still, there are several decisions which need to be made concerning projects affecting the future direction of the space program. They include: the construction of a new orbiter to replace the Challenger, the Space Station, space science missions and further development of advanced expendable launch vehicles.

Nearly three decades ago, it appeared that humankind had finally begun its conquest of outer space. The events of the early years brought to life scenarios that had previously been the material of science fiction writers. The late 1950s and the decade of the 1960s introduced many feats in space travel: the first artificial satellite, the first human in space, the first planetary probe, the first space walk, and the first human on the Moon. It seemed almost certain that the remaining decades of the 20th century would unveil the development of space stations and space colonies, trips to the planets, and perhaps even vacations in space. At least one forward-thinking individual envisioned building the first Hilton in space. Unfortunately, as we enter the final decade of the 1990s, few if any of these dreams appear to be forthcoming.

While it is probable that we will be actively involved in space exploration into the indefinite future, it is imperative to get the United States space program back on track. This chapter examines a variety of technical, socioeconomic, and political concepts that presently characterize space ventures being envisioned around the world.

A recent United States presidential commission called for an expansive agenda leading to a fleet of manned spaceports and permanent human settlements on the planet Mars and on the Moon by the year 2030. Some analysts argue that this type of grandiose national goal is "just what the doctor ordered" to revitalize the space program and re-establish America's position of leadership. Others suggest that this form of political goal setting will perpetuate and exacerbate (aggravate) the problems confronting the United States civilian space program. Up until now, this country's space community has repeatedly become obsessed with expensive programs that have not been dedicated to meeting any clearly defined long-term goals.

The National Aeronautics and Space Act of 1958 did not establish an aerospace trucking company; primarily, it did set up a research and development agency. If NASA continues to place numerous scientific projects on hold, it may be forced to redefine its primary role to the American public. Is it plausible (acceptable) for NASA to continue promoting its politically favored flagship programs such as the Shuttle, Space Station, and the Mars Colony, while it also conducts a vigorous unmanned program in applied technologies, exploration, and science? Before anyone can honestly attempt to respond to this inquiry, it is essential to determine first what we wish to accomplish in space and then identify the means through which these goals can be best attained.

1. In light of the space shuttle Challenger disaster, what should contemporary space transportation systems realistically be designed to accomplish?
2. The persistent challenges to colonize and industrialize space have become international in scope. What commercial ventures have been proposed as part of current space programs? What interest, if any, do national defense departments have in space development projects?
3. What are the primary technological objectives of the American satellite industry? What contributions has this industry made toward the social/scientific advancement of society?
4. What concerns have been expressed about prolonged periods of time spent "living" and "working" in space?
5. Are there any specific long range goals that should define international space policies? Would these goals insure future support?

KEY CONCEPTS

As you review this chapter, you should familiarize yourself with the following terms and phrases as they relate to space exploration:

Expendable Launchers
Space Recovery Vehicle (SRV)
Artificial Satellite
Arianespace
Electrophoresis
Geostationary Orbit
Skylab
Space Station
Bioastronautics
Space Adaptation Syndrome
Space Junk
Intelsat

THE CONQUEST AND INDUSTRIALIZATION OF OUTER SPACE

Outer space – for decades, it has been emotionally regarded and applauded as the final frontier. Its romance seemed almost blinding at times! Although the risks were always there and the failures of manmade spacecraft were statistically inevitable, we continued to press on with an ever increasing ration of the "pioneer spirit." The ability of mankind to conquer and industrialize outer space within our own lifetime seemed inevitable – Why?

One of the more prominent features of the earliest days of the "space age" during the late 1950s was the intense competition between the Soviet Union and the United States. Persons around the world were stunned in 1957 by the Soviets who successfully launched the first artificial satellite, Sputnik 1, into orbit. American scholars hung their heads and questioned the credibility of our educational system, the scientific community, and our technological leadership. The United States subsequently embarked on a breakneck pace scientific journey, containing a series of technological obstacles, in order to overtake the Soviets. Along the way, public support of the emergent space program was borne out of patriotism coupled with blind faith in new and exciting forms of technology.

In 1961, the Soviets were once again victorious after they sent the first human into space. The United States followed a few months later when Alan Shepard became the first American to be launched into outer space. It became evident that the Soviets were still ahead of the United States in most areas of space technology. Feeling frustrated and perhaps embarrassed, the Kennedy administration next challenged NASA to land a man on the moon before the close of the decade. The Apollo Moon Program was inaugurated and ultimately captured the hearts and minds of American men, women, and children throughout the 1960s. Apollo clearly represented a bid for national prestige and a demonstration of technological savvy.

The race wore on as NASA forged through its Mercury, Gemini, and Apollo programs. Throughout this series of missions, astronauts were commonly viewed as our heroes. The pressure of the space race forced us to underwrite the tremendous expense of each spacecraft launch. Congress approved each request that NASA submitted, culminating with a tremendous victory just five months before the close of the decade. Millions of viewers around the world were glued to their television screens as the Apollo 11 mission created another significant entry for our historical journals. Astronauts Neil Armstrong and Buzz Aldrin became the first men to take a walk on the moon – the United States had won the race.

The thrill of victory, however, was short lived. Congress grew tired of financing adventures that had, at least on the surface, the same plot each time. Government officials called for more scientific fieldwork and fewer "flashy" stunts performed by our nation's finest men. One example of the type of behavior that received national media coverage, much to NASA's chagrin, involved the 1971 lunar mission of Apollo 14. The major "scientific experiments" included Alan Shepard driving a golf ball and Edgar Mitchell attempting to send telepathic messages to fellow para-psychologists on Earth. Although Shepard did make the longest drive in the history of golf thanks to the moon's gravity, congressional expectations were far from satisfied.

The United States finished its abbreviated series of Apollo lunar landings one year later with a geologist on board Apollo 17. By this time, the American public had become somewhat disinterested and was trying to envision what its next space triumph would look like. On the flip side, the nation's leaders were not in any sort of agreement on what the next step should be for the space program. The magnificent success of the Apollo program was partially related to the fact that its goal was precise and short-term: Send a man to the moon and return him safely to Earth. We developed and refined the technology to accomplish that goal and then we stopped. Less than fifteen years after NASA had been formally inaugurated in the United States, its very existence was in a state of jeopardy. The follow-up Apollo-applications program was cancelled due to insufficient funding, and NASA did not have a long-range goal that could sustain the country's space program.

Under a certain amount of political and economic pressure, NASA officials decided to replay the Apollo technique. They contemplated the need for a costly, long-term project that would appeal to the hearts of the American people and therefore their congressional decision makers. NASA had previously initiated the idea of developing a reusable spacecraft after its first lunar landing when the nation was extremely concerned about numerous environmental issues. The central premise was that millions of wasted dollars could be saved by reusing the launcher's components (the boosters, the fuel tanks and the orbiter itself). NASA believed that a vehicle of this configuration would assure its survival since it would take many years and a large sum of money to develop, construct, and deploy. Out of this proposal emerged the Shuttle Project which is formally referred to as America's Space Transportation System (STS).

THE SAGA OF THE SHUTTLE

From its inception, the shuttle program was forced to operate under a fair amount of pressure. NASA's initial proposal to develop a reusable space shuttle for routine transportation into space was predicated on two main opinions:

1. Humanity belonged in space.
2. A permanent space station was the next logical step to putting the species "out there" on a long-term basis.

NASA further promoted the concept by saying that the space station would be serviced and restaffed by the shuttle. Payload costs on board the shuttle had to be kept low enough to make this type of activity affordable.

NASA placed itself squarely behind the shuttle project and proceeded to gain the support of numerous federal agencies. Specifically, it fought hard to attain the support of the Department of Defense (DOD) in order to assure White House approval. In doing so, NASA resolutely agreed to incorporate a number of military specifications into the shuttle design. For instance, the Air Force requested a huge payload bay measuring 15 by 60 feet, 60,000 pounds of lift capacity, and the ability to land on either the West or the East coast. At this time, military officials were mainly interested in launching large reconnaissance satellites ("Star Wars" had not yet been born). Even still, they also stipulated that the spacecraft should be able to return quickly from orbit and maneuver easily under threatening conditions. As you can well imagine, NASA immediately said farewell to any hopes it may have had for low developmental costs. NASA placed all of its space eggs in one basket and promised Congress that a fleet of five orbiters would be operational by the end of the 1970s. Its original cost estimate ranged between $5 and $6 billion.

Following its approval by the Nixon administration, the shuttle program got off the ground when Rockwell International won the design contract in

1972. Construction began two years later. Delays were encountered repeatedly along the way due to inadequate funding and continual problems with the main engines and heatshield tiles. Realizing that the shuttle project had severely overrun its budget, NASA made several decisions to scrap a variety of valuable research programs that were already in operation. One of the most memorable of these abandoned projects was SKYLAB, Figure 5.1.

SKYLAB was a preliminary version of a United States space station that had evolved during the Apollo era. NASA launched this huge orbiting space laboratory in 1973. In less than one year, three crews of astronauts visited SKYLAB and respectively spent one month, two months, and 84 days living and working inside the space station. During these visits, western scientists were finally given an opportunity to make an exhaustive study of the physiological effects of prolonged space flight. NASA's decision to abort the SKYLAB project resulted in its eventual demise. One of the first official tasks of the new shuttle vehicle was to visit SKYLAB and keep it functioning. Since the shuttle ran several years behind schedule, the largest Earth-orbiting satellite ever to be launched burned up in the atmosphere in 1979. Noting the irony of the fact that we no longer had a space station of some sort in orbit, some observers began to question the validity of the shuttle program.

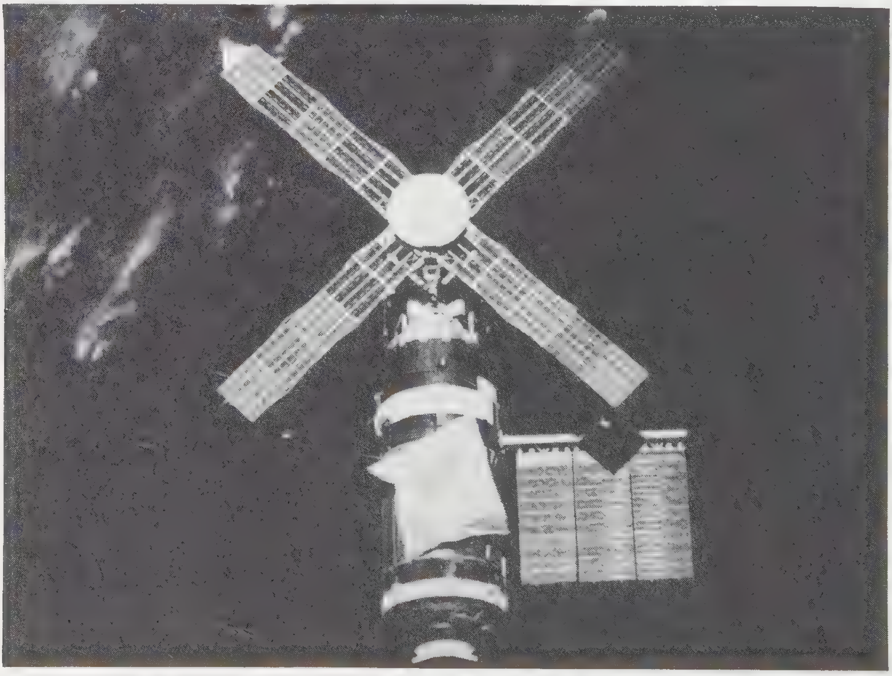


Figure 5.1 SKYLAB II on-board film release. Overhead view of Skylab space station, with clouds and star in background. Taken from Command Module during final "fly around" inspection. (NASA)

Plagued by a series of engine fires, the space transportation system schedule was modified and set back on a regular basis during the late 1970s. No one had built throttled liquid rockets of this size before. The problems of pressurizing, heating, and containing the explosive fuel were (and still are) quite formidable! Leaks, fires, and turbopump failures occurred over and over again. From the original target launch date of 1978, the shuttle slipped almost three years behind schedule when the first flight of the Columbia was finally launched in April 1981. Many of the technological bugs had not been worked out and the heat shield tiles had not been flight tested to insure the safe return of the astronauts. The cost of the project had approached the $11 billion mark by that point—nearly double NASA's initial projections.

Prior to the Challenger disaster in 1986, NASA successfully executed 24 shuttle flights over a four and a half year period. 1985 was by far the best year for the program with three shuttle orbiters in operation and nine successful flights. As impressive as this might sound, NASA's original projections during congressional hearings in the early 1970s indicated that each orbiter would be launched once each month after the program had gotten underway. In other words, they optimistically envisioned some 60 flights per year! A more realistic portrayal of their program is given in Figure 5.2 which presents an impressive flight schedule for the four shuttle orbiters that was prepared by NASA in mid-1985. These missions were subsequently delayed for several years.

Even before the 25th mission of the space shuttle program ended in a fatal explosion, experts had begun to question the economic viability of the star player in this country's space program. Costs per pound of payload were 20 to 50 times greater than NASA's initial projections. The base cost for a single launch rose from $50 million to $250 million. One of the main reasons for these very high operational costs for the shuttle stems from its most significant design feature—it must be operated with human beings on board. The life support systems and safety features necessary to make a spacecraft safe for human passengers weigh a lot. Simply stated, it cost more than half a million dollars to lift one astronaut (not including food or gear) aboard the shuttle during the mid-1980s. It is possible that these costs could be justified if scientific experiments or manufacturing procedures that required human input were the primary purpose of the shuttle. Through the mid-1980s however, the shuttle had been used mostly to deploy unmanned satellites. This type of task can be done more cost efficiently from expendable unmanned boosters such as the Ariane rockets being used by the European Space Agency (ESA).

On the other hand, NASA defenders insist that the shuttle is more cost effective than it seems. Launching satellites via conventional rockets also requires a costly launch system manned by armies of technicians. NASA firmly believes that the shuttle vehicle has proven it can fulfill multiple missions, from launching communications satellites to in-space repair of the satellites. They concede that the real economic dividends from scientific research may take longer, but remain convinced that they are forthcoming. The future shape of the space shuttle program is tentative. It has been recommended that the United

States phase out commercial and foreign payloads for the shuttle fleet after its current contracts have been fulfilled. The shuttle will most likely serve the Pentagon first, then the commercialization of space launch services will be encouraged.

1986 SPACE SHUTTLE LAUNCH SCHEDULE*

Mission	Shuttle	Launch Site	Launch Date	Other Payloads
**51-L	Challenger	Kennedy	January 22	Spartan-Halley (UV spectroscopy) TDRS-B (NASA relay comsat)
61-E	Columbia	Kennedy	March 6	ASTRO-Halley (UV imaging) Westar 7 (Western Union comsat)
62-A	Discovery	Vandenburg	March 20	DOD payload
61-F	Challenger	Kennedy	May 15	Ulysses (ESA solar polar mission)
61-G	Atlantis	Kennedy	May 21	Galileo (NASA Jupiter mission)
61-H	Columbia	Kennedy	June 24	EOS-1 (pharmaceuticals) MSL-4 (materials science lab) Skynet 4-A (UK Royal Navy comsat) Palapa B-3 (Indonesian comsat)
61-M	Challenger	Kennedy	July 15	TDRS-D (NASA relay comsat) INSAT 1-C (Indian comsat)
61-J	Atlantis	Kennedy	August 8	Space Telescope (astronomy)
61-K	Columbia	Kennedy	September 3	EOM-1/2 (solar energy experiment)
61-I	Challenger	Kennedy	September 24	LDEF (space exposure experiment) Intelsat IV-1 (comsat)
62-B	Discovery	Vandenburg	September 29	DOD payload
61-L	Atlantis	Kennedy	October 22	SHEAL-1 (x-ray astronomy) MSL-5 (materials science lab) DOD (military) STC DBS-A (commercial TVsat) ASC-2 (commercial comsat)
71-A	Columbia	Kennedy	October 30	ASTRO-2 (ultraviolet observatory) Spartan-2 (solar physics) HS 376-R
71-B	Challenger	Kennedy	November 26	DOD payload
71-C	Atlantis	Kennedy	December 15	Spartan-3 (ultraviolet imaging) DOD (military) STC DBS-B (commercial TVsat) Skynet 4-B (UK Royal Navy comsat)

*Source NASA; Based on its flight schedule set in June 1985.

**Mission 51-L of the Challenger was terminated by a disastrous explosion which claimed the lives of all seven crew members in January 1986; All remaining missions were subsequently postponed indefinitely.

Figure 5.2 Proposed shuttle flight schedule for 1986 as prepared by NASA in mid-1985.

BUSINESS IN SPACE

The American Space Transportation System (STS) was envisioned as the space equivalent of a trucking company that would offer frequent and routine service into orbit. Unfortunately, these expectations fell far short of being met when the shuttle hardly came close to paying for itself during the first few years of operation. NASA has struggled to regain momentum and has emerged from a temporary holding pattern with its shuttle project. In the meantime however, it appeared that the gauntlet had been thrown down to the United States aerospace industry to come up with private programs that can compete with Europe, Japan, China, and the Soviet Union for customers in space.

An entrepreneurial race began. Industrial representatives seem hopeful that their plans for commercial ventures in space will not be kept on hold too much longer. The American satellite industry voiced concern about the postponement of NASA's shuttle flights. Some representatives from satellite manufacturing and processing firms expressed the opinion that they would be out of business if the shuttle flight schedule did not resume quickly. Since NASA provided exclusive backing for the manned shuttle project for more than a decade, the United States was left without an arsenal of expendable launchers. The leading manufacturers of expendable rockets in this country during the mid-1980s included: General Dynamics (Atlas-Centaur), Martin Marietta (Titan) and McDonnell Douglas (Delta). Not one of these companies was scheduled to have any rockets available for commercial customers until the late 1980s. In order to even meet this time line, they may need to modify their existing production hardware to handle commercial requests as opposed to military specifications.

In the absence of ready-to-fly domestic launchers, the commercial satellite industry has begun to turn to foreign suppliers. Arianespace is a European company that is backed by fourteen governments and is held by the European Space Agency (ESA). Formed during the mid-1970s, ESA committed itself to applied scientific endeavors including communications satellites and the French Ariane heavy launch vehicle. The Ariane rocket program has received an impressive number of contracts to launch satellites. Its flights are booked solid through 1990. The French Ariane IV rocket can carry an 8000-pound payload into a geostationary orbit 22,300 miles above the Earth. Hughes Communications is a satellite operator owned by California-based Hughes Aircraft, the world's largest manufacturer of satellites. It has booked an Ariane launcher for a Japanese telecommunications satellite. Even the United States Department of Defense has negotiated with ESA for the deployment of an unclassified military-communications satellite.

The Soviet Union has also made an entrepreneurial move. It recently created an agency for space cooperation called Glavkosmos. This group has offered to launch satellites for paying customers aboard its tried and tested Proton rocket. Although customers must arrange for their own insurance coverage, the Soviet rate is reported to be about half that charged by Arianespace. The Soviet program is fully operational, but it will certainly have difficulty in attracting Western customers. At present, United States export-control laws forbid the shipment of any satellite containing American technology to the Soviet Union.

The Chinese and Japanese are further behind but are most assured competitors in this ongoing entrepreneurial contest. China's Long March 3 rocket has successfully launched two satellites. They presently hold future contracts for two more United States commercial satellites. The Japanese have an expendable launcher under development. Their H-2 rocket is scheduled for its first flight in the early 1990s. It is rapidly becoming obvious that the United States launch companies will need at least some indirect government subsidies if they are to be successful against foreign competition.

PROPOSED COMMERCIAL AND MANUFACTURING SPACE VENTURES

It is possible the communications satellites scheduled to be launched by the space shuttle can be shifted over to expendable launch vehicles. This is not the case for other planned commercial space projects. Specifically, those companies involved in materials processing or in-orbit servicing are vulnerable to the shuttle's scheduling setbacks. Their business plans are usually almost completely dependent on two-way transport to a low Earth orbit.

A few years ago, space commerce was touted by industrial and government officials as the next frontier for business. The space environment was depicted as an area of unlimited opportunity that promised billions of revenue dollars per year. NASA researchers described space-based factories that would ultimately be able to produce rare medications, computer chips, and other products impossible to fabricate on Earth. Figure 5.3 provides a partial list of companies who signed agreements with NASA prior to the Challenger accident. Even though the future outlook for these types of commercial ventures remains uncertain at the moment, it is essential you acquire an awareness of their potential for success. It would be impractical to list all the types of experiments and projects proposed to NASA, but a few selected examples are discussed in the following paragraphs.

The key feature of manufacturing in space is the extended period of weightlessness permitted in a low gravity environment. Gravity on Earth causes materials of different densities and temperatures to separate. Some materials actually deform under their own weight. Working in the microgravity of space enables scientists to use unique materials-processing techniques not feasible on Earth. For instance, in-space processing allows for an extremely high level of crystal purity and structural uniformity. It further permits researchers to mix and solidify metals and ceramics, or separate and purify biological materials more efficiently than on Earth. A report (pre-Challenger accident) provided by the Center for Space Policy (CSP) estimated the annual value of the space-related materials-processing industry could range from $2 to $17.9 billion. The entire commercial space business forecast ranged between $12 and $60 billion annually. Some economic analysts felt that these figures were

COMMERCIAL SPACE VENTURES

Company	Project Proposal
McDonnell Douglas Corp.	Electrophoresis operations in space.
Microgravity Research Associates	Materials processing in space experiments.
3M Corporation	Research in organic and polymer chemistry.
Martin Marietta Corp.	Research evaluation of fluid dynamics at zero gravity.
Orbital Sciences Corp.	Transfer Orbit State (TOS); upper stage research.
Fairchild Industries, Inc.	Development of free flying platform.
Space Industries, Inc.	Industrial space facility.
Transpace Carriers	Privatization of Delta expendable launch vehicle (ELV).
Deere & Company	Research in alloy formation.
DuPont	Research in catalytic materials.
Honeywell, Inc.	Materials research on crystalline structure.
Defense Systems, Inc.	Data relay satellite.
Rockwell International	Fluids experiment apparatus.
Boeing Corporation	Industrial space processing research program.
Grumman Aerospace Corp.	Materials processing in space; furnace experiments.

Figure 5.3 A partial list of companies who had signed agreements with NASA prior to the Challenger accident in January 1986.

misleading. Consequently, CSP discontinued making market projections for commercial space ventures.

Scientists have pointed out that successful space-manufactured products must be of great value and limited in volume to warrant the enormous costs for production. Generally speaking, these manufacturing ventures should also be next to impossible to achieve on Earth. NASA insists that there are products that possess these characteristics. To support their position, they cite a number of private companies that have pledged large investments to develop manufacturing techniques for making pharmaceuticals, synthetic materials, alloys, and crystals in space. Product research is well underway in the pharmaceuticals industry. It seems the peculiar condition of space enhances the refinement of biological materials for improved treatments of cancer, diabetes, and kidney disease.

Through the mid-1980s, St. Louis-based McDonnell Douglas Corporation was one of the leading firms actively involved in pharmaceuticals research with NASA. During their brief partnership with Ortho Pharmaceutical Corporation, they developed a production unit capable of separating materials in solution by subjecting them to an electrical field inside a restrictive chamber. This space-age manufacturing technique is called **continuous flow electrophoresis.** A static variation of this process is commonly used on Earth to separate and analyze the components of blood serums and other protein mixtures. Continuous flow is the key to this process in space.

The lack of gravity during space operations allows for greater concentrations of the sample materials. Yields can be 100 to 400 times greater than those produced on Earth. McDonnell Douglas has enthusiastically listed the following items as potential products of its future full-scale space-based drug plant pictured in Figure 5.4:

1. Growth-factor products for healing burns or surgical wounds.
2. Growth hormone products for pituitary gland problems such as dwarfism.
3. Antitrypsin products used for pulmonary diseases.
4. Drugs used to thicken the blood for use in hemophiliacs.

Another area under study is the development of ultrapure semiconductor crystals such as gallium arsenide (GaAs) for use in supercomputers and electronics devices. Gallium arsenide crystals conduct electrons 10 times faster than silicon, but they are more difficult to engineer. Some specialists believe science technology will figure prominently in the next generation of computers. One prominent firm involved in this research project is Florida-based Microgravity Research Associates, Inc. (MRA). This company entered a joint endeavor agreement with NASA during the early 1980s to demonstrate the superiority of GaAs crystal material produced in space. Representatives from MRA reported (since the Challenger incident) they had developed a process to make "space-quality" gallium arsenide crystals on the ground. Nevertheless, this company still plans to fly its shuttle experiment by the early 1990s.

Another joint enterprise, between NASA and Minnesota-based 3M Company, is designed to investigate the growth of organic crystals using two different processes: diffusive mixing of organic solutions (DMOS) and physical vapor transport of organic solids (PVTOS). See Figure 5.5. Experiments performed on board the shuttle during one of its 1985 flights produced pinhole-free thin films that had been impossible to grow on Earth. 3M's goal is to fabricate superior optical devices for applications in image processing. This product is projected for completion during the next five to ten years. 3M Company representatives have indicated they are ready to get on with their research and are hopeful their long-term agreement with NASA will remain intact. Some analysts feel NASA may not be willing to commit a lot of shuttle capacity to one company. 3M Company has requested 72 flight opportunities over a 10-year period.

Another significant area in materials processing involves the production of extremely light, high-strength substances. These may lead to a new generation of high performance airplanes and high strength, super insulating materials for use in homes, cars, and aircraft. NASA notes most examples of space-manufacture have the requisite low volume/high value features essential for a profit margin. During the mid-1980s, NASA offered free shuttle flights through its Joint Endeavor Agreements to any company wanting to test equip-

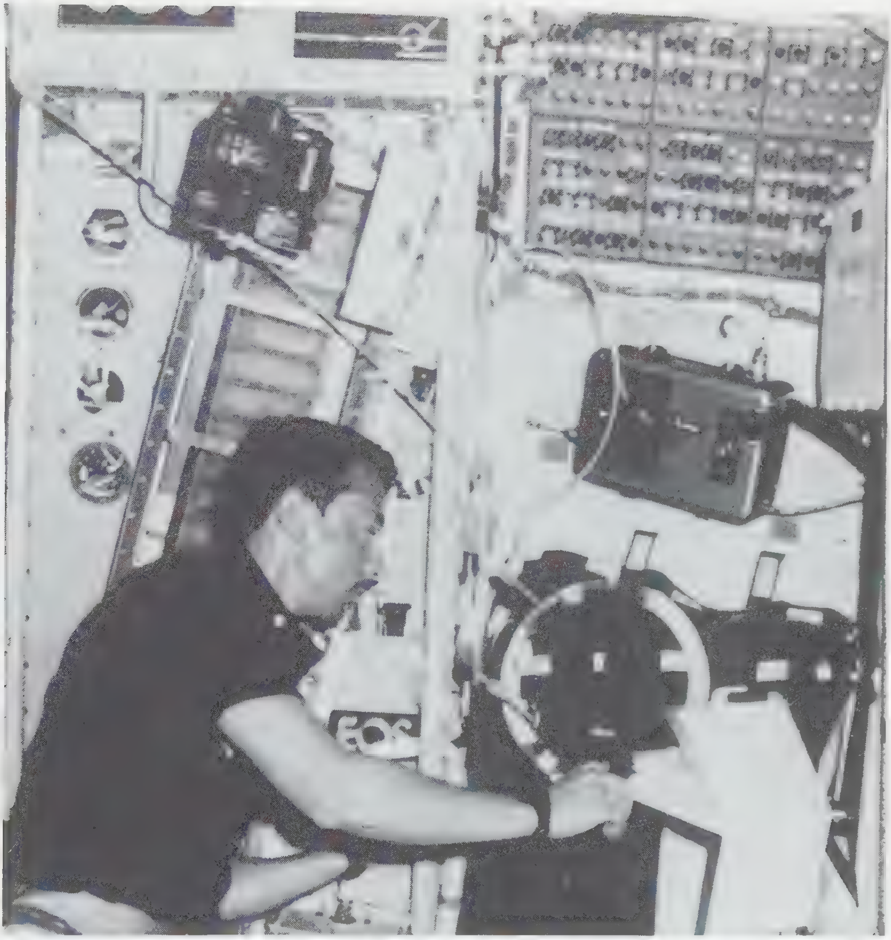


Figure 5.4 Space Commercialization. Charles Walker, McDonnell Douglas engineer, operates the company's processing experiment on a space shuttle flight. The process, called electrophoresis, is a company-sponsored space commercialization project. Continuous flow electrophoresis separates materials in solution by subjecting them to an electrical field. Mounted in the middeck of the space shuttle, the separation device consists of three parts: a fluid systems module where the separation takes place; a microcomputer to control the separation process; and a water-cooling module. The total system weighs about 700 pounds. The space shuttle provides the necessary electricity to power the unit and access to a cooling system to remove the heat generated by the process. (McDonnell Douglas Astronautics Company)

ment or technical procedures in space. These agreements stipulated that once a company reached the end of its experimental phase and entered into commercial production, it must begin paying full fare for its shuttle flights ("Super Saver Fares" were not mentioned).

Figure 5.5 Dr. Marc Radcliffe, principal investigator, (DMOS-2 Diffusive Mixing of Organic Solutions), inspects organic crystals grown aboard flight of space shuttle Discovery. Shown here are crystals grown in one of six football-size cells which made up the 3M experiment. (3M Company)

Through the mid-1980s, the only two companies who had taken advantage of the free shuttle trips were 3M Corporation and McDonnell Douglas Corporation. Both committed substantial amounts of resources to their space projects. At present, it is uncertain how long these corporate commitments will be maintained if researchers are restricted to ground experimentation. If they are forced to suspend space experimentation for several years, it is possible that widespread corporate interest and support for space research will be weakened considerably.

SPACE TELESCOPE

NASA refers to its $1.2 billion Hubble Space Telescope as mankind's window into the universe. Although its originally scheduled launch date was canceled, the space shuttle will eventually be used to send this 25,000 pound payload into orbit. The shuttle will also serve as a base from which astronauts will be able to service the telescope and make any necessary repairs by replacing various modular components.

The Space Telescope, pictured in Figure 5.6, is named after American astronomer, Edwin P. Hubble. It consists of an Optical Telescope Assembly, a Support Systems Module, and a series of sophisticated scientific instruments.

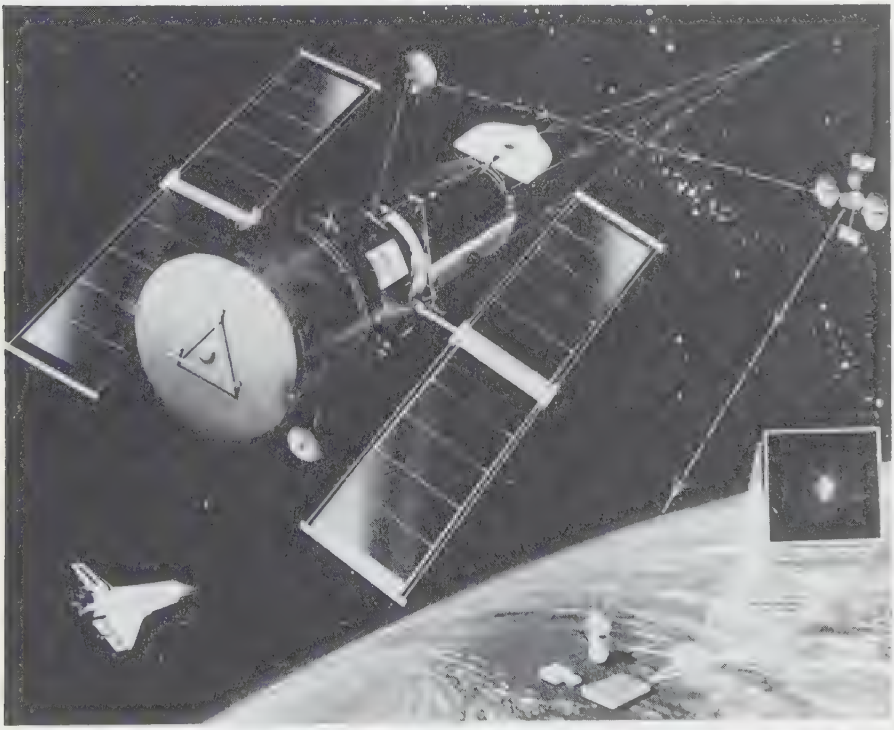


Figure 5.6. Artist conception of the Hubble Space Telescope in orbit with TDRS (Tracking & Data Relay Satellites), Shuttle Orbiter, and Ground Tracking System. NASA's Space Telescope is a multi-purpose optical telescope planned for launch into orbit by the Space Shuttle. It will enable man to piece together the puzzle of the universe. With it, scientists will be able to gaze seven times farther into space than ever before. For faint object photography, the Space Telescope will be effective at perhaps five magnitudes fainter than the same detection system on the ground. It will be remotely operated, using a TV-type recording system of much higher sensitivity than photographic films. This recorder is free from the limited storage range of photographic emulsion and permits very long periods of observation and even fainter magnitude limits. (NASA)

Refer to Figure 5-7. NASA scientists declare the difference between it and contemporary optical telescopes viewing the sky from ground observatories is analogous to the difference between Galileo's first telescope and the human eye. More specifically, consider these assertions:
1. Man's unaided eye limit = 600,000 light years distant.
2. Ground observatory limit = 2 Billion light years distant.
3. Hubble Space Telescope expected limit = 14 Billion light years distant.
Fourteen billion light years equates to a volume of space that is 350 times greater than can presently be seen from Earth.

The Space Telescope is designed to orbit the Earth at a nominal altitude of approximately 320 nautical miles with an orbital inclination of 28.5 degrees. Since it will not have the problem of the Earth's atmosphere blurring its view, astronomers will be able to take advantage of the telescope's clearer images to evaluate the mass, size, shape, age, and evolution of the universe in a more comprehensive manner. Scientists can look forward to viewing quasars, galaxies, gaseous nebulae, and Cepheid variable stars that are 50 times fainter than those seen by the most powerful Earth bound telescopes.

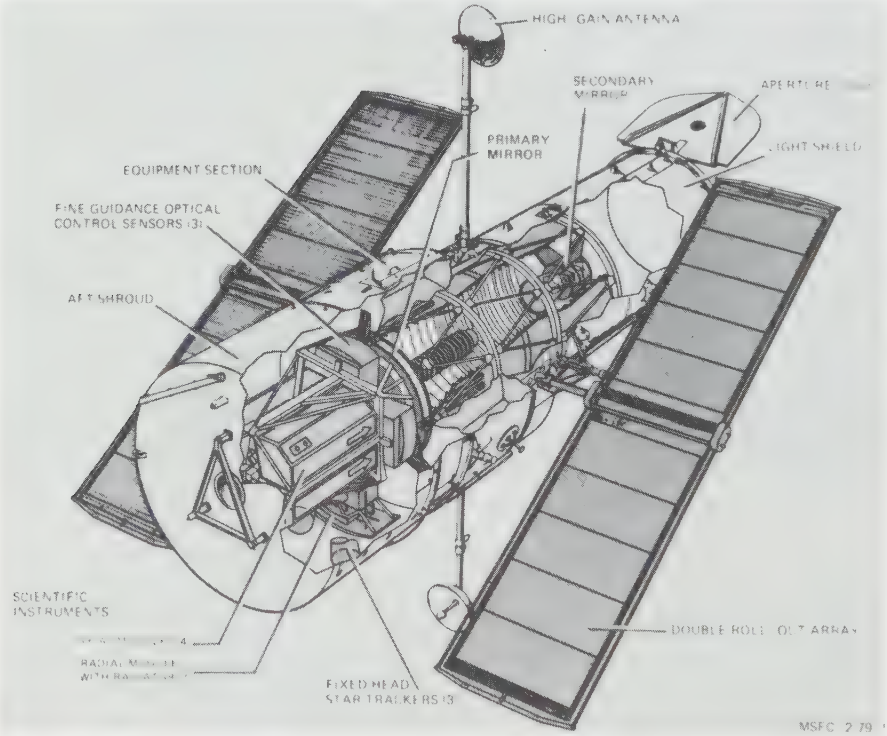

HIGH GAIN ANTENNA
SECONDARY MIRROR
APERTURE
LIGHT SHIELD
PRIMARY MIRROR
EQUIPMENT SECTION
FINE GUIDANCE OPTICAL CONTROL SENSORS (3)
AFT SHROUD
SCIENTIFIC INSTRUMENTS
4
RADIAL MODULE WITH RADIATOR
FIXED HEAD STAR TRACKERS (3)
DOUBLE ROLL OUT ARRAY
MSFC 2 79

Figure 5.7 A diagram of the primary components of the Hubble Space Telescope. (NASA)

Another possible use of the Space Telescope may be to search for planets which orbit other stars in the same manner Earth orbits the Sun. Cumulative data could enlighten us about basic physical processes in the universe and also indicate the possibilities for other life-supporting planets. The Hubble Space Telescope is also expected to further expand our knowledge of the energy processes in celestial objects, the early stages of solar-system formation, and the origin of the universes. Lockheed Missiles and Space Company (Sunnyvale, California) and Perkin-Elmer (Norwalk, Connecticut) are the two primary contractors for the Space Telescope. NASA is directing the program which is one of the most remarkable cooperative endeavors currently being pursued in our never-ending quest to conquer outer space!

SATELLITE SERVANTS

The successful launch of the first manmade satellite marked the beginning of man's exploration of outer space. Sometimes referred to as handymen of the heavens, artificial earth satellites transmit communications at the speed of light, serve as military sentries, and explore the universe itself. These electronic servants are used to locate mineral deposits, provide incredible records of the world's weather patterns, and guide ships through darkness and storms. Acting as silent spies in the sky, some satellites maintain surveillance that sustains peace in our volatile world.

Just how many objects are floating around "out there?" As incredible as it may sound, the North American Aerospace Defense Command (NORAD) center counted nearly 5000 pieces of hardware in orbit around the planet in the 1980s. They acknowledged the fact that close to 80% of those items could be classified as "space junk." For example, when satellites are launched into space, the rocket bodies, nose cones and spent fuel containers all remain in orbit for a certain period of time. NORAD tracks everything and watches objects as they fall from orbit in order to spot things that should *not* be there, such as enemy missiles. Less than three decades after the Soviet Union's surprise launch of Sputnik 1, NORAD tallied more than 14,000 man-made objects that had been shot into space. Even though two-thirds of these hardware specimens have since fallen back into the Earth's atmosphere and burned up (including the first Sputnik), it seems amazing that the remaining satellites don't bang into each other!

SATELLITE ORBITS

Just as artificial satellites come in a variety of shapes and sizes, so do their orbital paths around the Earth. A satellite positioned in a **geostationary** or **geosynchronous** orbit always stays in the same spot over the Equator. Located some 22,300 miles away from the planet surface, the satellites in this orbit move at the speed of the Earth's rotation. This type of an orbit provides a prime location for both meteorological and communications satellites. When viewed from Earth stations, these satellites appear to be standing still.

Generally speaking, satellites tend to remain in an orbital plane that is defined by the latitude of their launch sites. For example, a satellite that is launched from an equatorial site, like ESA's Ariane base in French Guiana, will remain in an equatorial orbit unless a correction is made. United States satellites launched from Cape Canaveral have a lesser angle of inclination with the Equator than Soviet satellites that are launched from higher latitudes. Elliptical orbits are useful for placing satellites that make scientific measurements, at differing altitudes, such as ozone levels. Satellites launched into a polar orbit can observe the entire surface of the Earth as the planet revolves beneath them. Polar orbits are commonly employed by the military to position their huge spy satellites. Finally, a sun-synchronous orbit is one that is inclined a few degrees beyond the Earth's pole. This type of orbit permits an imaging satellite, such as Landsat, to create its pictures with the sunlight always striking the Earth from the same angle.

By the early 1980s, the Soviet Union had launched over twice as many payloads as the United States (2069 vs. 997). These numbers do not tell the entire story however. During the same data collection period, NORAD estimated that there were approximately 290 satellites in orbit that were actually operational. Of these, over 180 belonged to the United States while the Soviets claimed just over 100. The remaining few belonged to several other countries and the ESA. In other words, a large percentage of Soviet payloads, such as platforms used to boost satellites into new orbits, had a useful life of only a few weeks. Most United States satellites were designed to function for much longer periods. Regardless of who owns them, man-made satellites ultimately lose momentum and therefore their altitude. Without additional servicing, their orbits decay and they fall into the atmosphere to disintegrate.

By definition, a satellite's **orbit** is a condition in which the pull of the Earth's gravity is matched by the outward fling of the craft's speed. There are an assortment of subtle pressures that may cause a satellite's orbit to decay, including solar flares and outer atmospheric disturbances. If a satellite starts to wander off course, watchful ground crews can systematically fire its small fuel jets that steer it back into orbit. This procedure must be used sparingly since the exhaustion of these gases spells the end of the spacecraft's useful career.

SATELLITE INDUSTRY DEVELOPMENTS

In just over thirty years, our society has become accustomed to its reliance on an assortment of satellites orbiting the globe. The broadcaster's phrase "Live Via Satellite" doesn't have nearly the luster it once had. These technological contraptions have become indispensable tools to the communications industry, scientific community, and our military personnel. It did not take long for space scientists to recognize the promise of satellites for the international communications network. Satellites were envisioned and described as great antenna towers in the sky that would be capable of transmitting messages almost instantaneously across oceans and land masses.

The United States became quite active in the satellite launching business during the early 1960s. Echo 1 became the world's first communications satellite and one of the largest man-made objects ever sent into orbit. This satellite was actually a huge mylar balloon covered with a thin coating of aluminum that was able to reflect radio signals from coast to coast. NASA launched the world's first weather satellite called Tiros 1. Equipped with twin television cameras, this spacefarer returned pictures of the Earth's surface for several months. These photographs were enthusiastically employed to monitor weather patterns. See Figure 5.8.

The Bell System's Telstar 1 satellite ushered in the era of live transatlantic television broadcasting. Unlike Echo 1 which passively bounced back signals, Telstar carried transponders powered by solar cells. These amplified signal strength thousands of times before relaying them to their destination. Telstar set a pattern for all following communications satellites. Since its orbit was low, it could only relay messages for short periods of time while it was in the correct position between sender and receiver. If a newsworthy event was taking place in Paris, you may or may not have been able to receive the televised

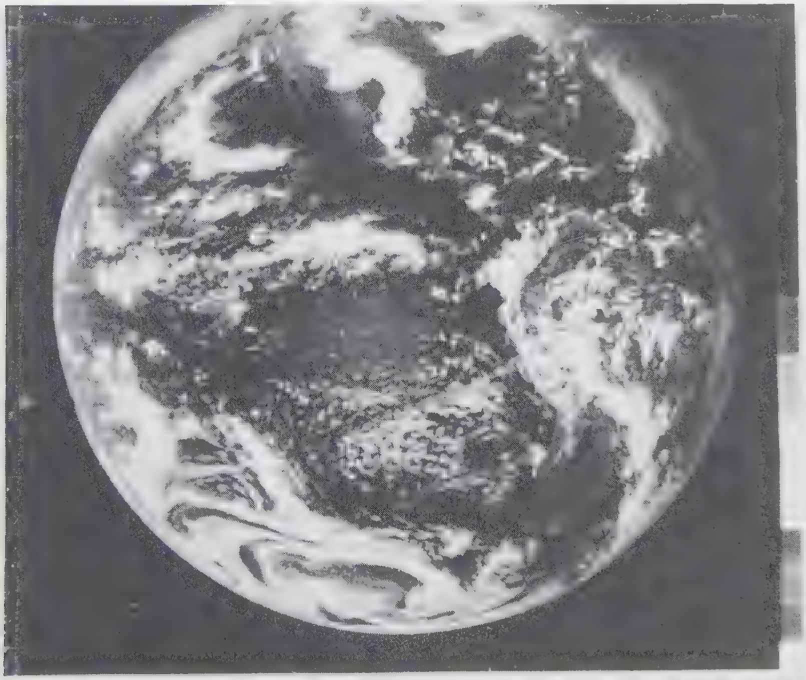

NASA ATS III MSSCC 21 JAN 68 191627Z SSP 94 95°W 00.61 S ALT 22240 83 SM

Figure 5.8 Applications Technological Satellite (ATS III) photo of North and South America. The photo was taken from a 22,300 mile altitude at 95 degrees West longitude above the equator. Cloud patterns and specific geographic areas are easily examined via this communication medium. (NASA)

report in New York. In other words, the geostationary belt had not yet been utilized successfully.

Intelsat I was soon launched into a geostationary orbit. Nicknamed "Early Bird," it provided the initial space link for a remarkable venture known as the International Telecommunications Satellite Organization (Intelsat). The Intelsat cooperative, headquartered in Washington, D.C., presently unites more than 100 members using more than fifteen communications satellites. The participating agency for the United States is the Communications Satellite Corporation (Comsat). Intelsat's newest satellite, Intelsat VI, can juggle at least 30,000 telephone calls and several television programs simultaneously! By humble comparison, Intelsat I relayed up to 240 calls and carried a single television station less than 25 years ago.

Several more benchmark events occurred in the field of satellite technology during the 1970s. NASA launched a series of Landsat satellites that sent back television-like pictures and infrared images of distinct features of the Earth's surface. These powerful tools have been instrumental in improving agricultural yields, locating oil and mineral deposits, and mapping optimal routes for railways and pipelines. Although the government has recommended that this system be absorbed by the private sector, its jurisdiction was recently shifted over to the National Oceanic and Atmospheric Administration (NOAA).

Numerous communications satellites were parked in the geostationary belt, including: Westars to service Western Union and customers who lease its transponders; Comstars, the flagships of the influential Comsat organization; and Aniks, sent aloft by Canada to create the world's first domestic satellite system. Indonesia, Japan and the European Space Agency each invested in orbiting communications stations. The United States military sector established a network that parallels the ones coordinated by Intelsat. The Federal Communications Commission (FCC) authorized a joint venture which became known as Satellite Business Systems. It was assembled to satellite-shuttle digitalized computer data among the nation's large corporations.

Satellite technology continued to progress and improve through the 1980s. With increasing frequency, military officials looked to the satellite industry for reconnaissance assistance. Subsequently, satellites are presently equipped with visible-light detectors that can "see" an enemy's weapons directly and infrared detectors that can sense the heat emitted by a rocket exhaust plume during tests. Navigational satellites are the workhorses of the military's Global Positioning System. These satellites will introduce a revolution in missile delivery.

One of the newest developments in satellite science was mentioned in the DATELINE section of this chapter. Standard satellite recovery vehicles are hollow capsules outfitted with a wide variety of payloads. They are often described as recoverable, and mostly reusable, space-based factory modules. Industrial proponents seem convinced that the same types of scientific and manufacturing endeavors that have been proposed for the space shuttle can also be executed aboard unmanned satellites.

Once in orbit, this automated factory will drift freely while the work is completed inside. Then, the reentry system is activated by a signal from the ground. This reentry may take place several hours or even several months after launching. A ballistic trajectory will bring the vehicle home. After entering the atmosphere, a drogue chute will pop at about 60,000 feet, pulling out the main parachute. Accuracy of these landings is projected to be within 50 feet of the designated target. The future for this segment of the satellite industry seems quite promising, especially in light of current debates regarding the extent to which technological proxies should be used instead of men and women to explore the universe.

LIVING AND WORKING IN SPACE

When Soviet cosmonaut Valentina Tereshkova became the first woman in space during the early 1960s, there was more than the normal amount of concern about her well-being. Although it was reported that she experienced some space sickness, she returned home essentially unscathed following a successful mission. She later married a fellow cosmonaut and they gave birth to a healthy daughter who was the first child to be born of parents who had both travelled in space. This incident allayed (calmed) some of the fears that space flight may expose human hereditary material to damaging radiation. Nevertheless, two decades passed by before either the United States or the Soviet Union included a woman on board its space vehicles.

Throughout the entire space program, NASA has studied and monitored astronauts' reactions to weightlessness and an assortment of conditions associated with prolonged periods of confinement. California-based Lockheed Missiles and Space Company recently identified more than 100 unresolved issues affecting the productivity of crew members during long-term missions on board an Earth-orbiting space station. NASA is presently pursuing a timely resolution of at least two of those issues it considers to be most critical—maintenance activities and contamination management.

Lockheed's study focused on the individual needs of a crew complement of six astronauts who will ultimately live and work on board the space station for up to 90 days. The research team included specialists in human factors, systems engineering, and industrial psychology. These scholars formulated a series of broadly defined human needs that require attention in order to provide adequate support for sustained productivity among space station crews. The critical support needs they identified can be categorized as follows:

☐ Physical health—Aspects of life and physical support that will contribute to the required crew performance.
☐ Psychological health—A sense of security, personal freedom, and an adequate social environment.
☐ Access—Visual and physical access within the microgravity environment.
☐ Motivation—Aspects of design and operations that will provide motivation for station crew members.

☐ Information/knowledge – Real-time status and feedback will be essential. Knowledge will be gained through training and continually updated documentation.

☐ Organizational structure – Aspects of organizational consideration and interpersonal interaction that will promote a favorable team effort.

☐ Tools and equipment – Provision of adequate human-engineered (ergonomic) items necessary to perform tasks efficiently.

☐ Performance capabilities – Crew member compatibility relative to the space program and specific mission should be criteria for selection.

☐ Stability in microgravity – Aspects of module layout, restraints, and physical as well as visual orientation that contribute to the human need for a feeling of equilibrium.

These major headings regarding human performance needs will serve as guidelines for NASA researchers involved in the development of design features and operational requirements for a permanently manned space station.

WORK STATIONS IN SPACE

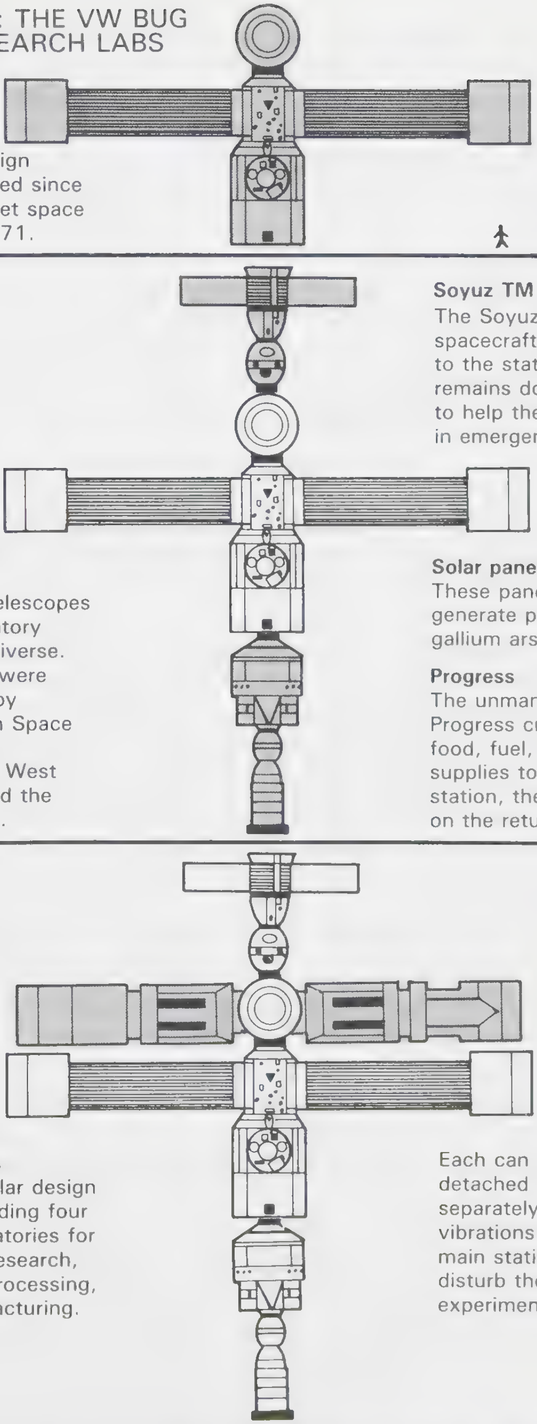
While the United States space program focused its energies on the shuttle program and held its sights firmly on the construction of a permanently manned Space Station, the Soviet Union made steady strides toward extending its civilization into space. The Soviets established the world's first space station in the early 1970s when it lofted Salyut 1. This habitat, about the size of a mobile home (one quarter the size of SKYLAB), housed a three member crew in a low Earth orbit for three weeks. During their flight, they conducted experiments on the effects of weightlessness on plants and human beings. Salyut 1 orbited Earth for close to six months before it was directed to descend and burn up in the atmosphere.

Since that time, the Soviet Union has launched at least six more Salyuts and earned a tremendous lead in the number of astronaut-days in space. Seventy-five percent of all manned experience in space through the mid-1980s belonged to the Soviet Union. Its cosmonauts have worked on board their Salyuts for more than eight months at a time. The longest American space mission on board SKYLAB was just under three months.

Salyut 6 was launched in the late 1970s. It remained in orbit for almost five years and was visited by sixteen different crews. These cosmonauts routinely performed in-orbit repairs and tested several furnaces for producing specialized materials. The station was resupplied on a regular basis by smaller docking craft called Progress service modules.

The Soviet Union boosted its successor to the Salyuts known as MIR (Peace) into a low Earth orbit. Scientists believe that this structure will probably become the world's first permanently manned space station. See Figure 5.9. Over the years, they have amassed a large volume of data and information describing the long-term effects of weightlessness, isolation, claustrophobic conditions, etc. Much of this information has slowly became available to the West, but

THE SOVIET MIR: THE VW BUG OF SPACE RESEARCH LABS



ORIGINAL STATION

The core design hasn't changed since the first Soviet space station in 1971.

Soyuz TM

The Soyuz TM spacecraft lifts crews to the station and remains docked there to help them escape in emergencies.

PRESENT STATION

Kvant astrophysics module

Four X-ray telescopes in this laboratory probe the universe. Instruments were contributed by the European Space Agency, the Netherlands, West Germany, and the Soviet Union.

Solar panels

These panels generate power with gallium arsenide cells.

Progress

The unmanned Progress craft ferries food, fuel, and supplies to the station, then burns up on the return trip.

FUTURE STATION

Kosmos laboratories

Mir's modular design calls for adding four more laboratories for biological research, materials processing, and manufacturing.

Each can be detached and flown separately so that vibrations from the main station will not disturb the experiments inside.

Figure 5.9 Simplified diagram of Soviet Space Station called MIR. (Mercury News)

the United States space program will become far more efficient when it is able to collect its own data on the effects of space living.

Following the delays created as a result of the Challenger accident, NASA remained committed to its goal to engineer and construct a fully operational manned space station by the early-to-mid-1990s. Estimates regarding the cost of this endeavor are projected around the $8 billion mark. The Space Station project is supposed to achieve several goals before the end of the century including: the encouragement of the commercialization of space; the promotion of international cooperation through active partnerships; and the continued advancement of space science and technology. Some view the project as the stepping stone to permanent life on the Moon or toward the procreation of the next generation entirely in outer space. At this point, screenwriters' images from the popular Star Trek television series begin to invade one's imagination.

Coming back to reality, NASA is extremely interested in the previously mentioned Lockheed research findings. These Lockheed scientists developed a list of space station elements that will affect the performance of the crews assigned to the station. Their recommendations were grouped into the following five categories:

1. Interior Architecture: New guidelines are needed to develop minimum volume requirements for crew activities in microgravity conditions. Additional research is needed to develop an optimal balance between multipurpose and dedicated activity areas. A variety of other items that required further study include: establishing a standard hatch size, defining a range of anthropometric limits to accommodate an international, mixed-sex crew under microgravity, optimizing traffic flow, selecting interior materials and decor, and developing food and equipment storage requirements.
2. Crew Support: It will be necessary to prepare internal atmosphere specifications that define minimum levels of humidity, temperature, ventilation rate, and crew comfort. Researchers must develop a specification for water quality and testing as well as its allocation for use in clothes washing or personal hygiene. Other areas demanding further study include waste/trash management, control of bacterial contaminants, and protection from radiation.
3. Crew Activities: Training methods and simulation requirements need further definition. Design concepts must be completed for efficient equipment arrangement to allow rapid access to all walls, bulkheads, hatches and seals must be developed. Tools and handling gear will need to be modified to be more convenient for use in a microgravity work environment.
4. Intravehicular Activity Systems: General guidelines are needed to create space station crew workstations. These are defined as locations where dedicated technical/scientific tasks will be carried out on a routine basis.
5. Intravehicular/Extravehicular Interface: The location, sizing, and design of airlocks within the space station must be determined. The Lockheed study

> recommended further research to estimate what communications links to the ground would be required, and to evaluate the role of the shuttle in supporting space station communications requirements.

It seems safe to speculate that a large chunk of the $8 billion space station budget will be expended in resolving these and other technical issues.

BIOASTRONAUTICS

When NASA selects you to ride the space shuttle, the chances are pretty high that one of your first experiences on board will be throwing up. Don't worry, you won't be the first to encounter this reaction! Within the astronaut corps, few emotional subjects are discussed more than "space sickness." Although it would rather not discuss its astronauts' complaints in public, NASA refers to this malady as "space adaptation syndrome." It continues to be a number one medical concern of space agencies internationally. Besides the urge to vomit, other undesirable effects of weightlessness include: lethargy, lack of appetite, drowsiness, stomach awareness, malaise, cold sweat, and nausea. As you can well imagine, even the most physically fit person's productivity level is bound to suffer radically under these conditions!

Researchers have found that humans gradually adapt to the microgravity environment and these afflictions tend to subside. This process of adaptation to an environment devoid of gravity (Z-gravity or zero-g) comes with a complement of other side effects however. The two Soviet cosmonauts who spent close to eight months aboard the Salyut 7 space station could barely stand up when they returned home. Their back and leg muscles had atrophied (decreased in size and strength) and their hearts had shrunk due to a severe loss in blood volume. Much of their calcium had been sapped from their bones. Amazingly enough, they both returned to their pre-flight conditions of strength and healthiness after a few weeks of physical therapy and massage.

Physicians and scientists who are interested in this process of adaptation and readaptation in all life forms have created an infant science called bioastronautics. Quite simply, **bioastronautics** is the study of life in space. The discipline grew out of sophisticated engineering feats directed toward a reconciliation or harmony between biology and hardware. This is the study of how technology can be used to sustain life (natural biological processes) in spacefaring vessels.

In recent years, bioastronautical studies have shown that space hardware is not necessarily synonymous with high technology. Consider the following example:

> One problem that space doctors were asked to confront involved how to restrain an incapacitated astronaut. NASA's first solution was a cumbersome and costly system of bungee cords. Their next solution came from a recommendation made by an astronaut who had ridden aboard Columbia on the fifth shuttle mission. He told medical experts to "use duct tape" to hold them in place! Apparently, he and his colleagues had used a lot of duct tape to stick things down on that particular voyage.

> . . Duct tape has since become a standard item in the on-board shuttle first aid kits.

An indirect consequence of this incident is related to the fact that hardware development is no longer the main preoccupation of bioastronautics research. In the past few years, increasing emphasis has been directed toward the study of physiological changes in zero-g.

The absence of gravity causes acute changes in the cardiovascular system, muscles, bones, metabolism, and even anatomy. As humans adapt to life in space, they disadapt to life on Earth. A sudden return to a one-g environment could overload a weakened heart or snap demineralized bones. Bioastronautics scientists are developing means to arrest the normal adaptive reflex that takes over during space flight, such as rigorous exercise regimens, supplemental minerals, mechanical devices to restore Earth-normal circulation of body fluids. Ongoing research investigations on human reproduction and the aging process are fascinating but their findings are still somewhat inconclusive. In other words, space doctors wonder—if biological adaptation were permitted to run its full course without interference, how would the changes affect reproduction, growth and the aging process?

It is possible that one of the most serious problems in bioastronautics at present has nothing to do with bioengineering, adaptation, or medicine. Regardless of their assignment, space doctors are generally crippled by a lack of useful data. Ask them a simple question: "Is heart disease more common among astronauts than among the U.S. general public?" Most physicians will tell you that the current sample of astronauts is not large enough to provide a valid response to your inquiry. The problems associated with obtaining reliable data are further aggravated by a fundamental rift between ground-based scientists and the astronauts themselves. Since astronauts insist on "limited veto" rights over medical experiments, many potentially significant studies never receive sanction.

In view of all the study remaining, bioastronautics has firmly established itself as a scientific discipline for the present and future space programs around the world. Mounting interest in space station habitation has led to enthusiasm in the space science community. Some space doctors hope their space biology, psychology, and sociology will produce yet another field of study—space civilization.

OUR FUTURE IN SPACE

For as long as historians have kept written records of society, they have been mindful of one simple tenet or principle: A civilization that ceases to explore begins to die. For more than three decades, government officials around the world have shown interest in space exploration, some more than others. It is no secret that the United States and the Soviet Union have been the primary players in this exploration game. The Soviet government has made slow but steady progress toward the attainment of a series of long term objectives which characterize its national space program. On the other side of the ocean, the

United States' program has made great technological leaps, some of which appeared on the scene in flashy, explosive spurts, toward the completion of short term projects. It is imperative for the United States government to make some hard decisions and then adhere to some reasonable long-term goals in space.

A few months after the Challenger disaster, the Presidential Commission on Space released a report entitled *Pioneering Our Space Frontier: The Next 50 Years in Space.* This one-year study culminated with a series of policy recommendations which may serve to get this nation's space program moving again. The report charted an ambitious and far sighted view of the future we should look forward to in our space program. A brief synopsis of their comprehensive recommendations is contained in Figure 5.10. The projected budget to pursue this aggressive course of action was set at $700 billion from the mid-1990s through the year 2020.

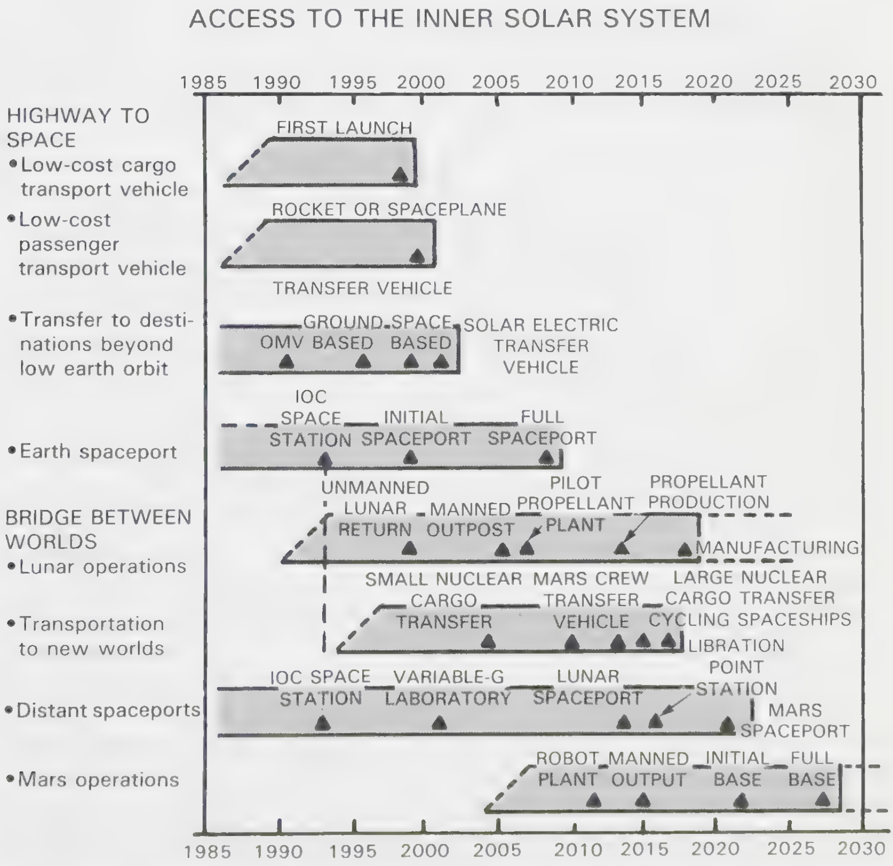


Figure 5.10 Illustrative timeline chart depicting the future of the United States space program. (National Commission on Space)

The immediate stages of the commission's program contemplates new technologies including the production of three new reusable space transport vehicles. The first is a low orbit cargo vehicle. The second is a passenger vessel that is smaller than the Shuttle for travel to and from a low Earth orbit. The third new orbiter is described as a "workhorse" transfer ship to carry both people and cargo beyond the Moon. This will also provide ferry service within the inner solar system (inter-space station/colony excursions). Some of the other recommendations in the commission's report describe proposals to:

1. Resume manned visits to the Moon. These should not be for brief expeditions, but for longer, systematic explorations culminating in permanent settlements. As a forerunner to human-tended outposts, NASA should consider launching a robotic lunar prospector to examine the entire surface of the moon.
2. Expand Earth-based and space-based searches for readily accessible asteroids. We should continue telescopic study of their surfaces and launch robotic mining missions to asteroids which show promise for mineral extractions.
3. Direct applied scientific efforts to assure that NASA's robotic technology program does not follow United States industry, but leads it.
4. Launch a sample return mission to Mars early in the first decade of the 21st century.
5. Provide for a dedicated, variable-g research facility in Earth orbit in the next few years. This base should be used to establish critical design features for future in-space facilities designated to be long-duration habitats.
6. Perform additional research in the construction and manufacture of space materials that do not require chemical separation. Moon and asteroid surface soils are mainly glass. Recent research suggests that these soil components can be processed into composites that are similar to glass fiber. This can be done without the need for energy-intensive chemical separation used for aluminum, titanium, or magnesium.
7. Construct self-sustaining biospheres (orbiting greenhouses) independent of Earth. It is believed that routine operations beyond the Moon will not be based on long supply lines back to Earth. It will be essential that life support be maintained using on-site planetary materials.

Recognize that this is not intended to be an exhaustive list of the commission's proposals. It should simply give you some idea of the types of goals it feels are attainable in the next few decades.

Even before these policy suggestions were presented to the Oval Office, the Soviets announced their intention to send an unmanned mission to Mars. The mission included landings on the two Mars moons, Phobos and Deimos. Accomplishment of this feat will be another first in space exploration. Soviet scientists reported that one purpose of the mission will be to explore potential reserves of fuel, oxygen, and water for use in a future Mars colony. Once again, the Soviet Union seems quite confident of its lead in the race to the "Red Planet."

In reworking long-term goals to formulate a national space policy, perhaps the United States should seriously consider cooperating with the Soviet Union rather than carrying on a competitive race. Both countries have individual areas of expertise. United States basic technology is superior and its computers are much more powerful and reliable. All of the Soviet manned space flights through the mid-1980s relied on a booster rocket designed in 1954 as a first-generation ICBM. On the other hand, Soviet experience with manned space flight and proficiency with automated rendezvous between space vessels are second to none. Further unification with the world's other space-exploring nations and the European Space Agency could lead to a multinational expedition to Mars. A challenge of this magnitude might actually foster global unity and a healthy attitude toward living together in harmony on this spaceship Earth! Stick around, it may very well happen in your lifetime!

SUMMARY

The age of space exploration is still in a state of infancy by comparison to other technological disciplines. Amidst the shadows of a great tragedy in this nation's space program, NASA's determination to keep moving ahead with its mission to investigate and conquer the frontier of space resulted in two successful shuttle flights in less than three years. Government officials gave favorable responses to NASA's requests for increased technical and financial support. The American general public, polled shortly after the Challenger accident, still believes in the need to continue with planned space flights.

It is difficult for most of us to imagine what it feels like to be lifted off the ground by huge rockets on board a vessel that is destined for an outer space journey. Unlike the early days of the astronaut program however, a greater number of persons who dream about space travel may actually earn the opportunity to pursue those dreams. Several futurist writers have prepared optimistic scenarios regarding space colonies and the development of a whole new civilization in space. Their portrayals of the future do not seem to exclude the layperson in favor of the scientist-astronaut. Other journalists paint a less optimistic view of our space program insisting that there are still too many unknowns and that a fair percentage of the knowns seem speculative.

Persons around the world have gazed up at the heavens for centuries. The technological devices that have been developed to enhance this age-old pastime are truly impressive. NASA is certainly not without its shortcomings, but its list of accomplishments cannot be ignored. The Soviets have broken numerous barriers to further the expansion of humanity into outer space. Organizations like Intelsat and Glavkosmos may soon create a spirit of international cooperation with reference to future commercial, scientific, and anthropological ventures into space. We have not only become intrigued by the mysteries of space travel, but we have also become accustomed to the technological by-products of its investigation. Outer space truly is mankind's final frontier—his destiny there will unfold for many years to come.

DISCUSSION QUESTIONS

1. Identify and describe at least three long-term projects on the horizon for NASA as it leads this nation's space program into the next century.
2. In your best judgement, what was NASA's primary motivation when it presented the Space Transportation System proposal to government officials in the early 1970s? If you had been a congressional representative at that time, would you have been favorable toward NASA's bid for financing? Why or why not?
3. Describe at least two commercial space venture proposals that will require manned space flights. What types of commercial objectives in space can be met using unmanned launch vehicles?
4. What is the difference between a geostationary orbit and a polar orbit? Explain why an operator would request either orbit for the location of its satellite.
5. Prepare a list of pros and cons that you would consider for critical evaluation before making a decision to spend 90 days working on board an orbiting space station.
6. Write a brief memorandum to an appropriate agency to request current information regarding present and future objectives of this nation's civilian space program. Be sure to keep a copy for your own records. One such agency is listed below.
   National Space Institute
   West Wing Suite 203
   600 Maryland Avenue SW
   Washington, D.C. 20024

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Chapter 6

BREAKTHROUGHS IN MEDICINE

DATELINE

Edmonton, Alberta Canada

In medicine, lasers are used primarily for cutting through tissue or sealing off blood vessels. Researchers at the University of Alberta are investigating the potential uses for lasers in dentistry—specifically as a tool in root canal therapy. In a conventional root canal procedure, the nerve-connecting pulp in the center of the tooth is scraped out and replaced with a rubbery material. This technique is unsuccessful if the small opening at the base of the tooth where the nerve exits is not completely sealed off. This may allow acid-producing bacteria to collect in the area which may trigger painful inflammation. This is where the laser may be useful.

These Edmonton scientists have used extracted human teeth to experiment with a remarkable new regimen for root canal work. High-powered carbon dioxide lasers have been used to fuse enamel plugs at the base of the root; they also discovered that short bursts of laser energy can sterilize and glaze the walls of the reamed out canal. A crucial step in developing the procedure for use in actual patients will be to develop a small laser generator and an accompanying beam-directing device that can fit in the person's mouth. Although the process may not be ready for human use for another several years, it is expected to be safe . . . .

INTRODUCTION

Most of the sociological surveys that have been conducted to determine how people feel about the advancement of technology seem to report at least one common finding. Respondents tend to be in general agreement with regard to the positive influence that technology has had on their physical well-being. Technology has made us healthier, and has certainly increased the average life span for human beings throughout the world. In other words, people often look to the medical discipline for examples of significant technological breakthroughs. More often than not, they seem to indicate that they have been successful in their search for advancements due to technology.

Technology has made numerous and diverse contributions to medicine over the years. Some historians use the medical field to chart the chronology of technology. It has become increasingly evident over the past few decades that medicine and the health care system in general have become dominated by science and technology in our society. At the core of most contemporary diagnostic and treatment procedures, one will find a host of technological devices (hardware) and control systems (software). These devices are the machines which can extend our human capabilities and serve to separate us from the perils of the natural environment. An assortment of computerized and electronic control techniques and systems have been developed to monitor, evaluate, and operate these devices.

We are living in a new era of medical miracles that may ultimately serve to correct many of our physical and mental afflictions. Some of the more visible medical forces that have entered the awesome war against injury, disease, and distress include: laser surgery, electronic pain killers, over-the-counter detection kits, in vitro fertilization, artificial organs and body parts, genetic therapy, and a variety of new vaccines. Individuals who would have had a minimal chance for survival less than 20 years ago can presently look forward to a normal, healthful existence. In some ways, these technological accomplishments have begun to serve the purposes that religious ritual once did. Stated differently, technology conveys the hope and promise of vitality.

Despite the many promises afforded by medical technology, some observers believe that the medical profession is experiencing overwhelming dependency on new technology. During the first half of this century, medicine focused largely on the observation of disease from a relatively passive clinical/diagnostic perspective. Today's medicine is dedicated to the aggressive treatment of disease from an applied scientific point of view. The medical profession embraces and endorses modern technology and the many contributions it has made to the diagnosis and treatment of its patients.

As with most other narratives concerning technological advancement, the blessings of modern medicine cannot be counted without also reviewing the negative aspects. It seems that the rise of medical technology should be paving the way for better medicine. On the contrary, the burden of absorbing new technical information has landed squarely on the physicians' shoulders. Doctors are confronted with the almost full-time problem of keeping up with new technologies and procedures in order to provide the best patient care (and to avoid malpractice suits). The pace of new discovery in the medical field is so intense, even recent graduates are likely to be out of date in a few years.

To make matters even more stressful, it seems that keeping up with the latest advances in one's own field of specialization is not enough any more. Doctors have become anxious about technology in general. In some cases, if they are not familiar with the latest discoveries in other fields, they may be deemed negligent for failing to make a referral. This seems to be a strange process to enforce quality in a discipline whose primary objective has always been expressed as the healing of the sick and injured.

Technology in the medical industry can be loosely defined as the rational selection and use of devices and procedures toward the achievement of measurable, useful, and relatively immediate human outcomes. There are both costs and benefits associated with the technological breakthroughs that have been made in health care. The aim of this chapter is to examine the current status of the nation's health care industry. Technology's influence is examined through a review of some of the major advances that have either taken place recently or are still being developed. The extent to which persons are able to afford many of these high-tech miracles is presented as an issue that demands much attention.

1. What are some of the critical issues needing to be addressed if the profile of the medical profession and the technology associated with it is to remain intact and unscathed?
2. Should medical specialists be instructed to become less dependent on "machines" in their treatments and diagnoses? In other words, is contemporary medicine addicted to a "technological fix?"
3. Why does it seem that what *can* be done in terms of health care technology (sustain life in a brain dead patient by machine) is a lot clearer and easier to understand than what *should* be done (shut down the machine)?
4. What sorts of moral and ethical concerns have surfaced as a result of medical breakthroughs in areas such as surgery and procreation?
5. What projections are being made with regard to the future cost of high-tech (or even low-tech) medical treatment? What is driving up the cost of health care in the United States?
6. How has the introduction of over-the-counter detection kits affected the role of the medical profession in society?

KEY CONCEPTS

In your reading of this chapter, you should acquire an understanding of the following terms and phrases:

Technology Overkill
Health Maintenance Organization (HMO)
Preferred Provider Organization (PPO)
Fluoroscopic X-ray
Noninvasive Surgery
"False Positives/Negatives"
Computerized Axial Tomography
In Vitro Fertilization
Diagnosis Related Groups (DRG)
Lithotripter
Arthroscope
Balloon Therapy
Psychotropic Drugs
Amniocentesis
Procreation
Nuclear Magnetic Resonance

A PROFILE OF THE HEALTH CARE INDUSTRY

More progress has been made in medicine over the past few decades than through all of history. Technological innovations including artificial joint replacements, artificial heart valves, the heart-lung machine, and cardiac pacemakers have been introduced. Refer to Figure 6.1. An assortment of medical procedures such as organ transplants, microsurgery, coronary by-pass surgery, kidney dialysis, and amniocentesis have been performed with increasing regularity and success. We have access to new diagnostic systems for studying the interior features of the body including computerized axial tomography and nuclear magnetic resonance. See Figure 6.2. A variety of new drugs, vaccines, and systems that permit diagnosis and treatment of cancer have also arrived on the scene.

This brief introduction barely scratches the surface of the numerous technological and scientific breakthroughs that have occurred in recent years. The benefits associated with these accomplishments are very noteworthy. The United States presently devotes more than 11 percent of it gross national product (GNP) to the medical and health care of its citizens! Figures computed during the mid-1980s revealed that approximately $387 billion per annum was spent on health care in this country. This staggering sum equated to almost $1500 for each American citizen in one year. Through the mid-1980s, the government provided slightly more than 40% of this per capita amount. A review of today's health care industry seems to indicate that the most critical issue revolves around strategies to contain these soaring costs in the years ahead.

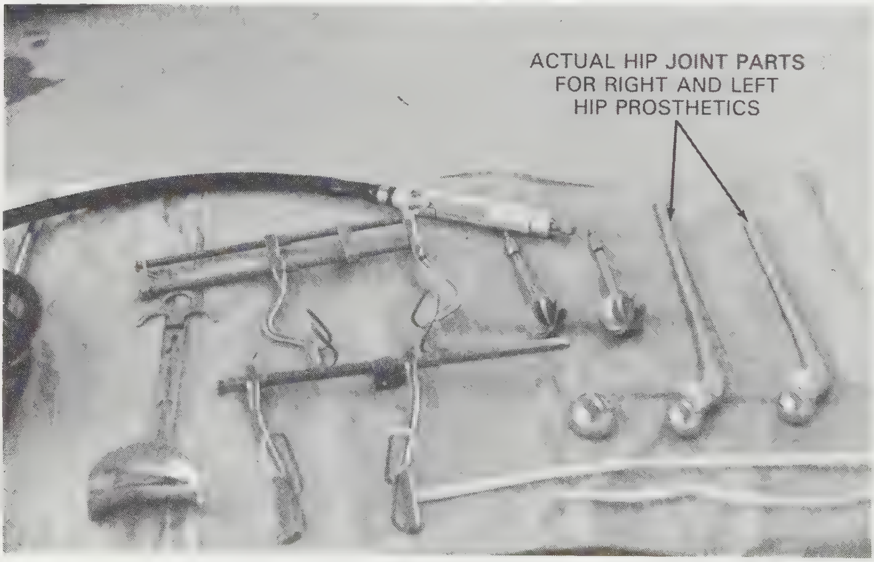

Figure 6.1 Surgical instruments required for the implantation of the artificial hip joint shown on the right portion of the tray. (Jonathan Davies)

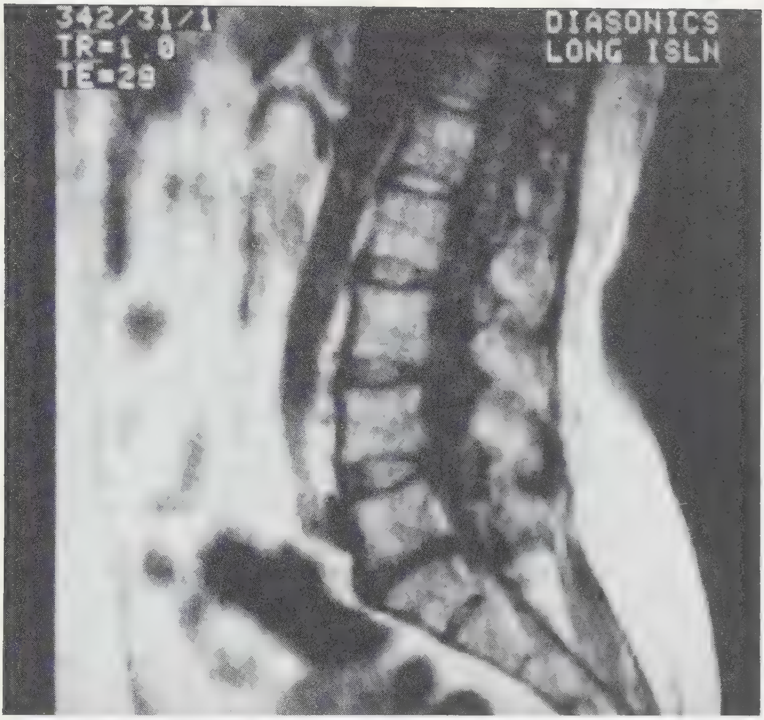

Figure 6.2 Radiology has emerged from the ranks of fuzzy pictures of broken bones to color images that diagnose brain disorders, heart attacks, and epileptic seizures. The image shown here is a product of an imaging technique called Nuclear Magnetic Resonance (NMR) spectroscopy. This highly sophisticated machine works by creating a very powerful magnetic field around the patient and bombarding him with radio waves. When these waves are withdrawn, hydrogen atoms in the body emit a radio signal that reflects the difference between healthy and damaged tissue. A primary advantage for the patient is the absence of radiation damage. (El Camino Hospital, Mountain View, CA)

The medical era preceding World War II was a bit simpler with regard to services rendered by practicing physicians. Most of these "family doctors" were generalists and most patients paid what they could afford for their own care. Since patients usually had to pay for medical services themselves, doctors often felt obligated to adjust their fees to their individual financial capabilities.

During this earlier time period, the ratio of physicians to patients was much lower than today. Most physicians had as many patients as they could handle. There was little economic incentive to do any more for an individual patient than was clearly essential. Sophisticated medical technology was not widely available. More often than not, primary care physicians were diagnosticians who had little more than their time, guidance, and advice to offer. All of this has changed as the technology and organization of medical practice have become more specialized, complex, and expensive.

The profile of the medical profession in the late 20th century portrays a dynamic interplay among several factors—medical care costs, technological changes, and health insurance packages. Furthermore, demographic data reveal that we are an aging society due to the "baby boom" generation. This fact is expected to raise the overall demand for health care well into the next century. The times are not calm for medical professionals. Individuals who are responsible for the practice of medicine to ensure our physical well-being are under a significant amount of pressure to change.

There are several other factors that are emerging to reshape health care systems in the United States. Some of these include government intervention, increasing competition among health care providers, changing health care delivery methods emphasizing outpatient treatment, and versatile reimbursement procedures. Most significantly, a growing pressure to contain exorbitant medical costs is emanating from the general public, governmental officials, insurers, and the business community at large.

The American Medical Association (AMA) conducted an attitude survey regarding these issues in the early 1980s. A majority of the physicians and laypersons questioned indicated that the cost of health care was their greatest concern. It has become imperative to determine what sorts of economic tradeoffs will ultimately be necessary to bring down the cost of health care to a tolerable level (perhaps less than 10% of the GNP, according to one health association administrator[1]).

This challenge is not unique to the United States. Medical care expenditures have heightened in many areas, particularly in economically developed and technologically advanced countries. In the mid-1980s, Switzerland, Sweden, and Italy each devoted similarly large percentages of their GNPs to health-related programs and projects. The following paragraphs depict some of the topics related to America's contemporary health care predicament.

INCREASED COMPETITION IN MEDICINE

One of the current public policy efforts to contain costs involves a procompetition theory. Advocates have proposed a system where:

1. Price is a supreme consideration in the purchase of medical care.
2. Providers of health care are placed at financial risk for their actions.
3. The rate of increase in federal health care spending is curtailed.

Proponents of greater competition in the medical sector have come to the conclusion that present insurance coverage and the resultant financial and organizational structures have led to higher medical costs. In addition, this insurance/institutional combination has been regularly identified as a primary cause for the inappropriate use of medical technology over the past several years.

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[1] See Weil, Thomas P. Procompetition or more regulation? *Health Care Management Review,* Summer 1985, *10*(3), pp. 27-35 for a discussion of current themes in health care policy.

We live in a society that is prone to seeking technological solutions to its problems. Part of this tendency is illustrated by our adoption and use of medical technology. Medical specialists have usually adopted and relied on technology more so than generalists due to their training. Hospitals have often invested in more expensive equipment in order to present a higher quality and more prestigious image to the local community. Furthermore, conventional financing plans and governmental policies seem to have stimulated the use of technology at almost any expense. Specifically, the buyers and users (patients and doctors) of technology were insulated from its cost while the providers (hospitals) of medical technology were rewarded with greater revenue from greater use. Projections indicate that these scenarios will decline considerably in a more competitive environment.

The push to reduce health care expenditures has stimulated competition in the medical-care market. Refer to Figure 6.3. Hospitals are running advertisements. The names and services of physicians appear on the nation's billboards. Traditional fee-for-service providers are beginning to face a lot more competition from new forms of provider organizations. There has already been a significant change in how various services are delivered to those in need. For instance, free-standing urgicenters and ambulatory surgery centers have been developed. Also, the number of diagnostic services being provided in physicians' offices has increased steadily.

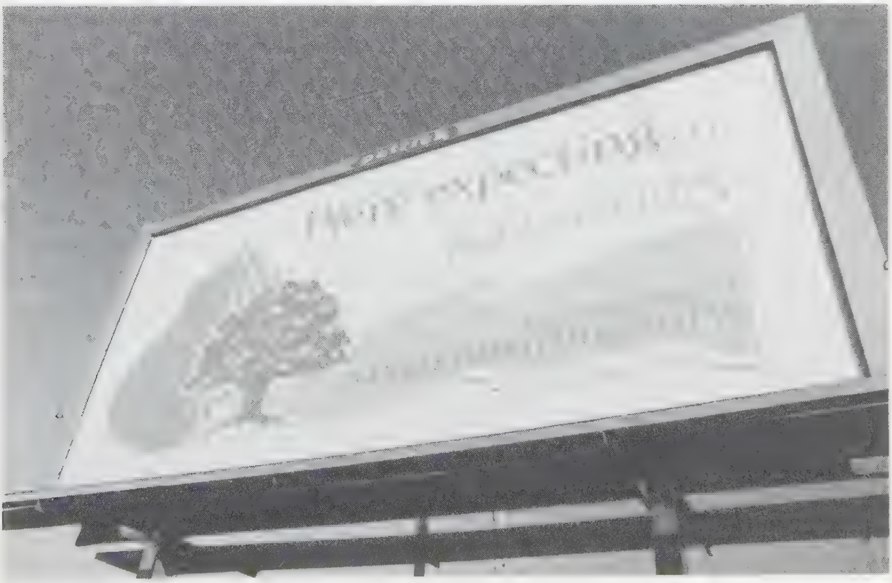

Figure 6.3 The advent of a variety of medical programs has stimulated hospitals to invest in less than conventional mediums for their advertisements. This billboard speaks to expecting parents who may be interested in the alternative birthing programs being offered by this medical institution. (Michael Dafferner)

More competition will ultimately provide a wider range of health care alternatives for individuals. Economists generally agree that more options are better for the consumer. (A word of caution here! The reality of this tenet is valid as long as consumers are sufficiently well-informed to make wise choices.) Many of us already have difficulty judging the quality of the health care we are receiving. It is possible that our level of confusion will be proportionate to the amount of competition that surfaces in the medical profession.

MEDICAL CARE ALTERNATIVES

The steady rise in health care costs has produced a variety of medical plans. The major payers of health insurance premiums are the government and private employers. Each of these has initiated steps to eliminate the incentives for excessive treatment, utilization, and abuse of technology.

Diagnosis-Related Groups (DRGs)

A while back, Medicare began a phased transition toward a new payment system for hospitals based on uniform payments according to diagnosis-related groups (DRGs). Instead of being reimbursed for Medicare patients on the basis of charges or costs, hospitals will be paid fixed sums for each type of patient by diagnosis. Medicare patients account for approximately one third of the care provided by hospitals.

This revised payment system works by assigning each Medicare patient admitted to a hospital to one of some 468 DRGs, based on the nature of the illness. Each DRG has a specific rate of payment with a built-in economic incentive. A hospital that treats a patient for less than the DRG price can keep the difference. If the treatment costs more, the hospitals must absorb the loss.

DRG prices were established on the basis of the nationwide average costs for treatment. For example, the payment for simple pneumonia (DRG 89) was set at around $3700. This figure is fixed regardless of the patient's actual needs or the method of treatment the health care provider selects. Survey statistics revealed that the average patient spends 8.5 days in the hospital during treatment for simple pneumonia. The underlying premise is that hospitals with above average costs per diagnosis will eventually reduce those costs to more closely approximate the DRG payment. On the other hand, they could just as easily shift these costs over to the private sector.

Fee-for-Service Payment

Fee-for-service medical care was standard practice when health insurance was introduced at mid-century. Insurance programs were designed to pay the participant's health care bills. In this system, an annual premium is paid. In return, the insurance company pays for at least a portion of an individual's medical bills. Through the years, these plans have become more complete and health insurance has often been buried in the benefits packages offered by employers. Subsequently, employees have seemingly lost sight of the fact that the medical treatments they receive are costing money. Some observers contend that this situation has given patients and doctors alike an inclination to buy or recommend excessive amounts of medical care regardless of expense.

The bulk of fee-for-service coverage is provided by:

1. Medicare—federal program for retired persons.
2. Medicaid—state programs for low-income people.
3. Blue Cross/Blue Shield—non-profit organizations that offer coverage for hospitalization and doctors' fees respectively.

The advantage of fee-for-service coverage is that the patient can choose any desired provider. Any qualified physician who offers a recognized health-care service can submit a bill to the insurer. If any emergency occurs, care can be sought at any site with the expectation of at lease partial reimbursement. Virtually anyone can buy individual insurance to cover fee-for-service care, but the cost for an individual policy may not be affordable for the average, middle-income wage earner.

Pre-Paid Health Plans

The most notable alternatives to traditional fee-for-service providers are known as **health maintenance organizations** (HMOs). HMOs, like the DRG system, utilize a fixed payment plan. In this type of medical plan, the provider offers a binding estimate of what a given amount of health care will cost the average patient for a one year period. Individuals who enroll in the plan pay that amount annually. If total costs go higher than the sum of these prepayments, the HMO loses money. If the costs stay below the estimate, the HMO operates in the black.

In actuality, the HMO is a merger of an insurer and a provider of health care. As an insurance company, it collects annual premiums from subscribers and then absorbs the risk that this cumulative income will cover its expenses. As a provider of medical services, it has its own staff of physicians and may also contract services out to other facilities. The theory is that HMOs have an incentive to deliver quality health care and also stay within their budget.

Critics of pre-paid plans hold that HMOs can often place too much pressure on doctors to limit care for the sake of protecting their profit margin. They usually make reference to a desireable feature of traditional fee-for-service plans wherein the price of medical treatment is not as likely to affect its selection or recommendation. Physicians employed within this type of structure may be more convinced that it is financially worthwhile to care for difficult cases.

An emergent strategy that seeks to preserve this aspect of traditional health plans is known as the **preferred provider organization** (PPO). PPOs are hospitals or groups of physicians that offer their services at a fixed price in exchange for a guaranteed supply of patients. The insurer (business firm, production facility, state agency) represents its clients by initiating a cost comparison search within the medical marketplace. It next contracts with a group of providers who agree on a predetermined list of charges for all services rendered. After the rate is paid, the patients are covered for the medical care services offered by the list of preferred providers. These types of arrangements represent an alternative to traditional health care packages.

Upon first glance, it may seem that the options for health care coverage are becoming too overwhelming. We may ultimately look back on the decade of the 1980s as a period of experimentation. In any event, it is evident that our society is determined to develop a system wherein the highest quality of medical care is provided at the most reasonable price. The medical profession cannot allow the pressures to cut costs to have an adverse effect on the quality of treatment administered. It is also essential to recognize that theoretical arguments can be made in favor of each of the above described programs.

TECHNOLOGY'S EFFECT ON MEDICAL COSTS

Economists tell us that increase in demand is one of the main factors contributing to rising costs of health care in this country. Several agents have fueled this increase including the widespread availability of health insurance, changes in our lifestyle, an awareness of the effects of the environment on our physical well-being, a larger and more specialized population of health care providers and technological progress. Advances in medical technology have increased demand by offering diagnostic and therapeutic procedures that were previously not available. To give one example, even though the pros and cons regarding its safety and cost effectiveness are still being weighed, many couples still request ultrasound for fetal monitoring during pregnancy. This illustrates the "if the technology exists, then use it" syndrome.

The benefits associated with technological advances in medicine are usually accompanied by a list of social costs. Some of the recent developments have actually lowered the cost of health care: the polio vaccine eliminated the need for the expensive iron lung; the rubella vaccine reduced the incidence of disease among pregnant women and cut down on the birth of mentally retarded babies. The use of psychotropic (mind-stimulating) drugs in the treatment of mentally ill patients has also yielded expenditure-cutting results. On the flip side of the coin, the conquest of infectious diseases such as pneumonia has increased our life expectancy. The most dramatic improvements can be seen for those who have chronic conditions. These persons seemingly remain alive to incur high health care costs long after they have been "cured." Advances in surgical techniques have also influenced health care expenses.

We have witnessed a series of major technological breakthroughs in medical science over the last several years. Educational programs have been televisied which show benchmark organ transplants and the development of artificial joints and organs. Some media professionals conceptualize an analogy where human body parts are almost as available as automobile engine components. Refer to Figure 6.4. The "parts list" presented does not include labor charges for installation!

All joking aside, the price tags attached to most of the technological miracles we read about are startling. Liver transplants are possible today due to the recent development of the drug cyclosporine. This immunosuppressant permits

HUMAN BODY ''PARTS'' LIST	
Leg or Arm	$1,000-3,000
Elbow	1,200
Ankle	700
Blood Vessel	300
Toe Joint	99
Ear	10,000
Heart valve	2,000
Heart (complete)	50,000-80,000

Figure 6.4 Table exhibiting a price list for human body parts. Originally published in an article in the New York Times, the prices may vary widely. (Weisbrod-America's Health-Care Dilemma)

the transplant to work by suppressing the body's immune-system reaction to the new organ without stopping its ability to fight off infections. A single liver transplant may cost around $200,000 at the time of the operation and another $20,000 per year afterward.

Through the mid-1980s, over $200 million had been spent on developing artificial hearts. Research conducted by the Office of Technology Assessment estimated that over 30,000 people each year could "benefit" from this technological device. The annual bill for these operations and follow-up treatments would most likely approach $3 billion.[2] A more distressing element of this report questions the degree to which costly artificial heart surgery produces significant results. They concluded that recipients could only expect to add six months to their lives.[3] The "quality" of this prolonged existence is somewhat debateable.

The widespread use of the now common coronary-artery bypass operation is also being questioned in some cost conscious circles. During the mid-1970s, approximately 60,000 such operations were performed each year. By the mid-1980s, that annual number had more than tripled to 200,000. This surgical procedure is said to cost around $20,000. Simple arithmetic indicates that some $4 billion was being spent on a form of medical treatment that some specialists still question. The evidence that the bypass reduces chest pain is substantial, but its benefits in the form of lesser risks of heart attack and increased longevity are ambiguous.

Continued research efforts will probably add to the complexity of the technology/cost/human need problem. The concept of technology overkill will not disappear in the near future. In a general sense, technological progress in medicine often makes what *can* be done much clearer than what *should* be done. The numerous technical manipulations and procedures *can* be defined with much conviction. It is far more difficult to decide when and where such technological interventions *should* be utilized.

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[2] *Federal Policies and the Medical Devices Industry.* U.S. Congress. Office of Technology Assessment. Washington, D.C., 1984 (GPO Stock No. 052-003-00965-0)

[3] At the time of this writing, Dr. William DeVries was the only U.S. surgeon licensed to implant permanent artificial hearts in humans. All of five of his patients had died within a span of less than three years.

If advanced technology continues to inflate the cost of health care, it may no longer be accessible to all persons who may be able to benefit from its use. Some medical experts believe we may be approaching a day when we will be forced to confront the rationing of costly high-tech procedures. Making life-and-death decisions about the use of costly medical technology is an exercise in which few legislators and even fewer doctors want to engage.

Over the past three decades, technological success in medicine has intensified political pressure for public access to the advances. The subsequent expansion of health insurance coverage increased access to new technology. Insurance coverage also provided incentives to develop newer, more effective, and inevitably more costly technological devices. Coming to grips with the cyclic nature of this dilemma may be the central challenge for the present generation of medical professionals.

CONTEMPORARY TECHNOLOGY IN MEDICINE

Several recent medical technology breakthroughs were mentioned briefly in previous sections of this chapter. The next subheadings endeavor to summarize the technical explanations as well as the social ramifications of a few of these "miraculous feats." These examples are accompanied by a host of other equally important diagnostic and therapeutic techniques which are totally reshaping the way we practice medicine today.

At the onset of the 20th century, the average life expectancy for American men and women was less than 50 years. Today, these figures exceed 70 years for men and women alike. Changes in lifestyle certainly account for a significant portion of this gain, but recent discoveries in medicine have also played a major role. As with other fields of specialization, the force of science and technology to change the way our bodies feel and function continues to accelerate at a breakneck pace. It is not surprising that medical knowledge is said to double every 4-5 years. (You should probably realize this rate of change in critical facts and figures is not unique to the medical industry—it is a characteristic of most contemporary fields of technology.)

Today's doctors continue to make inroads toward developing treatments for various forms of cancer. They regularly discover the potential uses for high voltage radiation, lasers, and radioactive beads implanted near a tumor for sustaining the lives of cancer patients. Other patients who suffer with chronic pain are being aided with electrical devices that shoot pulsing currents through the affected areas of the body.

Ongoing research in genetic engineering promises to influence the course of medical history. Some current developments in gene-splicing and genetic therapy were discussed in Chapter 2. Scientists have learned how to probe the genetic blueprint of the human body. Vaccine researchers have begun to master the processes required to isolate and reproduce antigens in order to formulate "ideal" vaccines. A number of drug companies are working on genetically engineered antigen vaccines for herpes, gonorrhea, hepatitis, and malaria. Also under development are vaccines that may prevent dental decay.

Gene-splicing technologists have also brightened the outlook for heart attack patients. They have successfully produced an agent called t-PA (for tissue-type plasminogen activator) which has been clinically tested. This natural human blood substance may be more effective in dissolving the blood clots which provoke heart attacks than streptokinase (the drug that has been widely used for this procedure in recent years). Gene therapy, while still in its experimental stages, may one day enable us to overcome inherited genetic diseases. Scientists believe they will have a complete map of the human genetic makeup before the end of the century.

The dream of a bionic body is seemingly becoming a reality. Doctors indicate that they can replace the heart, pancreas, kidneys, ears, limbs, blood vessels and hip joints with synthetic devices, See Figure 6.5. In some cases, the man-made technology may actually function better than its organic counterpart!

Figure 6.5 Surgical procedure involving a hip joint replacement.
(El Camino Hospital, Mountain View, CA)

Balloon dilation therapy, formally referred to as balloon angioplasty, has the potential to replace coronary by-pass surgery for opening clogged arteries. This procedure can be performed by snaking a guide wire up a patient's leg vein into the heart and pulmonary artery. A balloon-tipped catheter is threaded over the wire. At the proper location, the balloon is filled with fluid and expanded for several seconds to clear the clogged area of fatty deposits. This medical procedure can be done for one-fourth the cost of by-pass surgery and the period required for patient convalescence is significantly shorter.

Surgeons have begun to replace organs with plastic parts and vaporize tumors with laser rays. They are learning to perform delicate, life-saving operations on human fetuses in utero. A surgical technique called arthroscopy is facilitating the treatment of joint problems and sports injuries, as well as improving the diagnostic accuracy of knee pain situations. It appears we live in an era when some new spectacular medical discovery is reported almost every day. Perhaps we can look forward to a world where safe and effective medical tools and techniques are evident to combat any organism that causes disease among humans?

Still, medical progress has its share of bottlenecks. Doctors are stymied by the complexities of acquired-immune-deficiency syndrome (AIDS). The virus has been identified (which is in itself laudable). However, an effective AIDS vaccine is not expected to be widely available for several years. Science is not always invincible on the battleground of disease. Many diseases, from Alzheimers to lung cancer, still elude the healing touch of medical specialists.

To complicate matters further, medical breakthroughs generally do not emerge overnight—they are often forced to go through a series of political obstacle courses. The Food and Drug Administration (FDA) is the regulatory agency that decides which drugs and devices will be allowed to be used. Some researchers view the FDA as a bureaucratic barrier to innovation. Others hold that it does not require sufficient laboratory tests before human patients are allowed to serve as guinea pigs.

Then, too, there is the issue of the medical-entrepreneur. As with genetic engineering, research on artificial body parts has spawned a number of private industrial start-up firms. The flagship technologies developed in these centers may prove to be controversial amidst cost-conscious groups and those who are skeptical about the quality of the research conducted. Nevertheless, as is illustrated in the following paragraphs that deal with surgery and procreation, medical science is persistent in the face of these obstructions.

NONINVASIVE SURGERY

Noninvasive surgery means the patient's body will be penetrated by a laser beam or a shock wave instead of a scalpel. Non-touch, high-tech medicine may be considerably less traumatic and ultimately more affordable for the person receiving treatment.

Laser is an acronym for "Light Amplification by Stimulated Emission of Radiation." A laser consists of a glass rod or tube that is filled with a gas whose molecules can be stimulated to produce an intensely powerful, concentrated beam of light. Today's sophisticated lasers use many different gases (argon, carbon dioxide, krypton, etc.) that shine at varying wavelengths. In surgery such as the dental procedure described in the DATELINE section of this chapter, the laser beam simultaneously cuts and coagulates the tissue at which it is directed. In laser stitching inside the body, the beam of light fuses the protein of the tissues. As the wound heals, the coagulated tissue is absorbed by the body and replaced by new proteins.

For women, gynecological laser surgery has been shown to be a safe and effective alternative to having a hysterectomy. In performing this noninvasive technique, the physician uses a 10-inch long telescopic instrument called a hysteroscope. This tool is inserted into the endometrial cavity through the cervical canal. At the tip of the scope are optical fibers and lenses which enable the physician to view the walls of the cavity and locate the problem. Another optical fiber that transmits the laser beam is next threaded through a small channel in the hysteroscope.

One laser beam that has been used successfully in hysteroscopic surgery is based on a trivalent metallic element of the rare-earth group, known as neodymium: Yttrium Aluminum Garnet and abbreviated as Nd:YAG. The cost of this surgical procedure is significantly less than the standard charges for conventional open surgery. It also eliminates most of the postoperative problems such as pain from incisions, intestinal cramping, and extensive recuperation periods. Since the laser cauterizes as it vaporizes tissue, it stops bleeding and reduces the chances of infection and hemorrhaging.

Hysteroscopic laser surgery represents one of many applications for the Nd:YAG laser. This laser beam can be transmitted through optical fibers in thin tubes (technically called endoscopes) that are inserted into hollow organs of the body. This characteristic makes the technique equally useful in pulmonary medicine, urology, and gastroenterology.

Another form of noninvasive surgery employs the use of an arthroscope to repair injured joints. The **arthroscope** is a sophisticated needle-like metal device that houses a fiber optic light source. It is only two to six millimeters wide. See Figure 6.6. It can easily be inserted, under local anesthesia, into a knee, ankle, hip, shoulder, or wrist joint through a small puncture. Surgical arthroscopy may soon render many old-fashioned open-joint operations obsolete. Conventional joint surgeries require general anesthesia, longer stays in the hospital, and extended recovery periods. For example, a surgeon can use the arthroscope to repair damaged knee cartilage. The physician inserts this small viewing instrument into the knee joint through a 1/4-inch incision. Working through the scope and two additional 1/2-inch incisions, the surgeon can insert slim surgical implements to repair the damaged cartilage. Although some persons may require general anesthesia, the entire procedure can be viewed on a television with the patient wide awake.

An even more futuristic-sounding noninvasive surgical procedure is called extracorporeal shock-wave lithotripsy which involves a machine called a

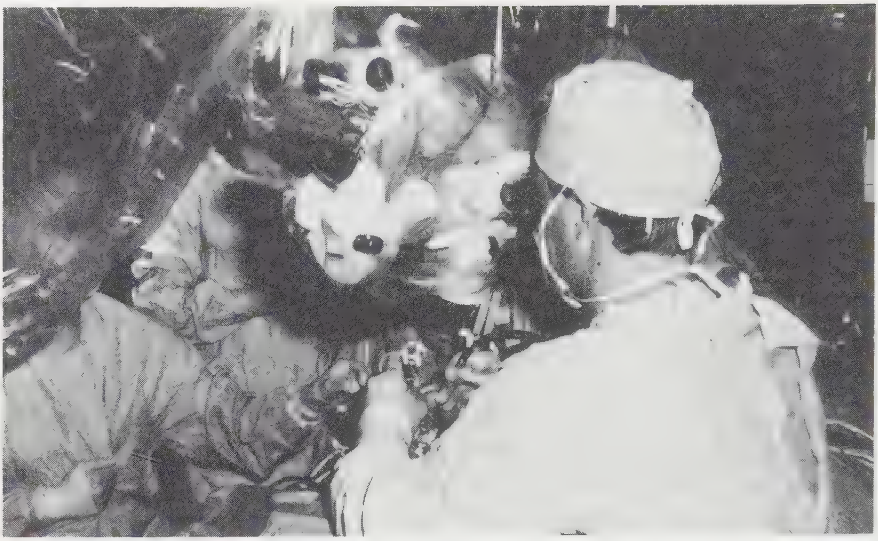

Figure 6.6 Arthroscopic knee surgery. A small viewing instrument, called an arthroscope, is inserted into the patient's body through a 1/4-inch incision. An arthroscope is a needle-like metal device with a fiberoptic light source inside. It is two to six millimeters wide. It can be inserted into a knee, ankle, hip, shoulder, or wrist joint through a small puncture under local anesthesia. The surgeon works through the scope and two additional 1/2-inch incisions through which slim surgical tools are inserted to repair the damaged knee cartilage in the procedure shown here. (El Camino Hospital, Mountain View, CA)

lithotripter. This million dollar piece of equipment uses shock waves to fragment kidney stones inside the body. Manufactured by Dornier Systems, it was approved by the FDA in late-1984. In less than one year, over 5000 patients received lithotriptic treatment for kidney stones. To make effective use of this technology, it is first necessary to perform a series of exploratory tests to determine the position of the stones and how well the patient's kidneys are functioning.

Following this pre-treatment phase, if the technique is deemed appropriate, the patient is prepped for the procedure and given general anesthesia. The person's lower body is immersed in a water bath and an underwater electrode is used to emit bursts of shock waves to the site of the kidney stones. The waves are administered at a rate and rhythm that corresponds to the patient's heartbeat. Throughout the procedure, two fluoroscopic X-ray units are attached to television monitors to help the doctor pinpoint the exact location of the stones. The procedure may take an hour or more, but the remnants of the stones can usually be passed through the patient's ureter (flushed out of the body) without difficulty the following day. Although lithotripsy costs more than the standard operation, the patient normally saves time and money in the long run because the hospital stay is much shorter.

In light of the fact that noninvasive surgical techniques are becoming more widely accepted and available, prospective patients should be aware of the drawbacks. In lithotripsy, if the shock waves are improperly focused, they can damage the kidneys and other internal organs. The fluoroscopes used in this technique emit radiation equivalent to the dosage of standard diagnostic rays. Other side effects such as internal bleeding and blockages may also occur.

To date, arthroscopy and laser surgery appear to have a low incidence of side effects. However, they are not foolproof. Laser surgery is heat-intensive and repeated treatments may cause permanent tissue damage. The person who opts for arthroscopy may ultimately need to undergo further treatment or even open surgery if the ligaments or tendons need more work.

Individuals are also advised to review their medical insurance coverage to determine policies regarding noninvasive surgery. Insurance is presently available for most laser and arthroscopic techniques. It may be a few years before the average policy covers lithotripsy due to the fact this procedure is still new.

PROCREATION

"Where do babies come from?" is a timeless childhood inquiry with has some new and somewhat provocative answers these days. Advances in medical technology have essentially revolutionized the process of human reproduction. Around the world, childless couples have started to investigate a variety of reproductive-assisting options including: in vitro fertilization, artificial insemination, surrogate motherhood, embryonic transfer and cryopreservation.

In vitro fertilization (IVF) is the procedure where eggs are removed from a woman's ovaries and fertilized outside her body by the father's sperm in a laboratory dish. Once conception "takes," the fertilized egg is reimplanted in the woman's uterus. In order to have any chance for success, IVF requires a number of well-timed and executed procedural steps. The woman who cannot conceive is first given hormones to induce her ovaries to produce more than one egg during her next cycle. Hormonal levels are closely monitored to detect the precise moment at which the eggs are ripening. To extract an egg from the ovary, a small incision is made in the patient's abdomen through which a fine hollow needle is inserted. The mature egg is deftly retrieved and placed in a medium that further enhances maturation prior to fertilization.

Comparatively, the father's sperm are obtained and placed in a carrier solution that prolongs its ability to fertilize the ovum. The two mediums containing the eggs and sperm are combined and diluted to simulate the normal conditions found in the fallopian tubes. The resulting zygote is transferred to another solution that supports cell division and allows the embryo to mature. Some 48 to 72 hours later, the embryo is transferred into the mother's body. A large percentage of the embryos transferred by IVF medical teams fail to implant in the uterus and repeated attempts are usually necessary. The first "test-tube" baby was born in England in 1978.

One *social* innovation that has culminated from technological experiments in human reproduction is a phenomenon entitled **surrogate motherhood**. A typical situation occurs when an infertile woman and her husband enter into a contractual agreement with another woman. The surrogate agrees to be artificially inseminated with the husband's sperm. After carrying the resulting fetus to term, she is expected to return the child to the original couple after it is born. In these instances, the baby has the genetic characteristics of the father and the surrogate mother. Another variation of surrogate motherhood arises when an egg from the woman is fertilized with her husband's sperm in vitro and the resulting embryo is implanted in the surrogate's uterus.

As you can well imagine, the physical and emotional commitment of the surrogate mother is substantial. Much of the anguish associated with pregnancy can not be offset by financial remuneration. The couple is obliged to the surrogate and must generally rely on her good faith to relinquish the child.

Embryo transfer is another reproduction-assisting technology that has become available to couples who are unable to conceive a child on their own. This technology may be employed for women who cannot produce eggs but can carry a fetus to term. Once again, the couple pays a fee to a fertile woman who agrees to be inseminated with the husband's sperm. It is critical for this egg donor to be "matched" with the wife in terms of their ovulation cycles. Also, the hormone levels must be the same in both women for a successful transfer to be possible. Four to five days after fertilization, the embryo is flushed out of the female egg donor and inserted into the wife's uterus. A variation of this procedure is known as embryo adoption where the sperm are provided by a male donor other than the woman's husband. As with IVF procedures, the success ratio for these procreation options is not that high.

Through a technology known as **cryopreservation**, a woman's eggs can be fertilized and cooled to minus-321 degrees Fahrenheit in liquid nitrogen. It is plausible that embryos could remain frozen in that state for centuries awaiting implantation in a human uterus. This technology could enable a young couple in their twenties to preserve their own genetic offspring to be borne at a later point in their marriage. In other words, neither partner would need to be fearful of infertility and the proverbial "biological timeclock" might not seem as threatening. Frozen embryos present a host of major ethical and legal concerns; some of these are reviewed in the next section.

Adjoining these scientific procedures designed to assist in the reproductive process are several prenatal diagnostic technologies. Medical scientists have made monumental efforts to identify and eventually treat a wide array of chromosomal abnormalities, metabolic disorders, and other hereditary diseases. Among others, their research has developed and popularized the following procedures:

☐ **Amniocentesis.** A long, thin needle attached to a syringe is inserted through the lower wall of the pregnant woman's abdomen. The amniotic fluid, which contains some live body cells shed by the fetus, is withdrawn. The chromosomes are karyotyped (test showing the sum of the specific characteristics of a cell nucleus including chromosome number, form, size, and points of spindle attachment) in order to identify any abnormalities and determine the sex of the fetus. If the fetus is found to have a severe chromosomal or metabolic disorder, therapeutic abortion may be offered to the mother. This procedure is normally performed early in the second trimester of pregnancy.

☐ **Ultrasound.** This procedure uses sound waves directed into the abdomen of the pregnant woman. "Pulse-echo" sonography presents a visual image of the fetus, uterus, placenta and other internal features. This noninvasive technology is painless for the patient and reduces the need for X-ray scanning procedures. Ultrasound is one of the medical breakthroughs which may lead to the further use of in utero fetal treatments.

☐ *Fetoscopy.* This application of fiber-optics technology enables the doctor to study the fetus inside the uterus. The fetoscope is inserted through an incision in the woman's abdomen under the direction of ultrasound. Fetoscopy has been used to give blood transfusions to diseased fetuses. Fetal treatments are still in their early stages. Fetoscopy has considerable potential for introducing medicines, cell transplants or genetic materials into developing fetuses to treat a number of diseases in utero.

ETHICAL ASPECTS OF HIGH-TECH MEDICINE

It is difficult, if not impossible, to begin to understand the health care system in our society today without recognizing the pervasive influence of technology. Medical professionals, patients, and business leaders have attributed positive values to numerous technical procedures and devices used to treat illness and prolong life. Technology has become the core of modern medical diagnosis and treatment. In achieving that stature, technology often has the power to divert the attention of health care providers from issues of human value to the expedient selection of technological solutions. In other words, many of the scientific miracles in our midst are raising difficult ethical questions about how these life-saving tools should be used. The decisions regarding who should pay for this treatment also looms over the heads of our medical policymakers.

Some researchers are suggesting one of the most basic precepts of the medical profession may no longer be useful or even valid. For centuries, physicians abided by the philosophy they should do everything in their power to sustain the lives of their patients. This basic belief has become confused by new medical technologies and the economic realities of contemporary medical practice. We have reached a point where living longer may not necessarily mean living better. Quality of existence may not be an issue that receives much attention when technical decisions are being made.

Some of the powerful new drugs used to combat serious diseases may cause psychological damage to the patient who places too much hope in their healing potential. A traditional interpretation of healing has been the process of helping people lead a full existence by giving them a greater measure of control over their bodies. Modern life-support technologies may be truly irresistible, but they often evade this goal. New technologies have the ability to keep various tissues disease free. The machines of technology are often used to sustain life that many persons would not deem worth living. In such situations, death may no longer be viewed as part of the natural order of man's existence, but as a failure of medical technology.

High-tech medicine may provide society with a reduced incidence of disease, but the costs are enormous. Technology in medicine often alienates the patient from the health care professionals themselves. Issues of human value can be obscured by the beeps and squeals of the cardiac monitor, the printed output of a CAT scan, or the sound of a bedside respirator. High-tech medical procedures can often interfere with family support mechanisms that have historically served as a source of encouragement for a person's well-being and sense of self-esteem.

On the economic front, the scenario looks even more complicated and disturbing. It has become quite apparent that there is a definite limit to the economic resources we can devote to health care. Governmental officials have repeated that we may have exceeded those limits for the past several years. In this setting, how can we decide who should receive these new forms of treatment and, in some cases, who should not get them? Major organ replacement is both technology-intensive and cost-intensive; it provides a visible example of this ethical quagmire.

Organ transplantation is unique among modern medical technologies because it is dependent upon human tissue obtained through consent. This characteristic places constraints on the use of this potentially life-saving procedure when the supply of suitable donors falls short of the demand. Our present system of organ donation and retrieval needs improvement. Perhaps a portion of the health care dollar should be directed toward the further establishment of regional, non-profit organ banks.

Some medical observers and professionals alike advocate a system of presumed consent. This means the organs of an individual who dies may be used, unless he or she has explicitly forbidden that use. This type of system has already been instituted in several European countries. A policy with these parameters places the burden of dissension on the individual. Some individuals and groups resist this approach and view it as a legislative intrusion. Think about this for a moment. Have you ever contemplated being an organ donor? Do you feel that this is a decision that you alone should be allowed to make?

Let us assume the demand for human organs exceeds the supply and the cost for the necessary surgical procedures is off the chart. Then, the process of establishing the criteria for selecting the beneficiaries of new transplant technologies poses another ethical issue. It often seems the patients with families who have the ability to attract public attention and can also afford the steep price of transplantation are the first ones chosen for available organ donations. While it is still debateable as to whether or not total expenditures for organ replacement should be a matter of public policy, an individual's ability to pay should not affect the decision to replace a failing organ. It seems both moral and logical to base the choice on the person's medical need and the extent to which the results are projected to be beneficial for the long term.

These criteria still would require an accounting of the cause of organ failure, the age of the patient, the availability of a suitable donor, and the ability of the patient to recover. For instance, a good candidate for a heart transplant might be a previously healthy young adult who has a terminal heart disease that is unresponsive to therapy. With this in mind, is the middle-aged adult who has a history of alcoholism a less desireable candidate for a costly liver transplant? How would you respond to this question if you were on a hospital patient selection committee? Future decisions concerning organ replacement or any new technology will not be any easier to make from the ethical/moral perspective. Economic constraints may inevitably lead to mandatory rationing of certain medical technologies. The medical profession will have to agree on a credible list of criteria for the selection of patients who are "good risks" for organ transplant surgery.

The subject of technology and procreation also prompts an array of difficult legal and ethical questions. Who ultimately has legal and moral responsibility to care for the progeny (offspring) of "artificial" procreation? Who decides what is best for a child when the traditional mother-father roles are no longer precise? Will surrogate motherhood become commercialized in the next several years? What sorts of emotional reactions might occur when a person learns that he or she is the product of the fertilization of an anonymous donor sperm and donor egg in a petri dish? What is an embryo's moral status?

This last question is crucial when, for example, an IVF team creates more embryos in the laboratory than can be safely reimplanted in the mother's womb. Disposing of these "surplus" embryos or using them for further research purposes opposes the view held by some that an embryo is a human being who has a right to life. Others say that until the embryo develops to the point at which it is capable of "experiencing" something it is not plausible to view it as a human being.

The recent scientific feats in cryopreservation may lead to an increased practice of freezing embryos with a view toward later implantation. The controversial side of this technique stems from a concern for the offspring. To date, a very small number of frozen embryos have been successfully thawed, implanted in the mother's womb, and carried to term. The necessary data are insufficient to evaluate the degree of risk to children who are created in this manner. An even more disturbing question arises if the parents die without leaving specific instructions about the disposal of the embryos (who its parents should be, when it should be thawed and reimplanted, where it should be raised, etc.).

Medical technology will probably not cease to advance due to an absence of answers for these and other ethical inquiries. The responsibility for directing the course of its development and utilization remains with all of society. While a small percentage of the population will join the ranks of tomorrow's medical specialists, most will continue to play the role of consumer and/or beneficiary. Value-laden decisions about new technology in medicine must be shared by both sectors.

TRENDS TOWARD SELF-DIAGNOSIS

In less than a decade after the first home pregnancy tests were introduced on the market in the late 1970s, a whole new generation of sophisticated self-diagnostic products began to appear on drug store shelves. A walk down the aisles of the local convenience store might reveal do-it-yourself devices for pinpointing ovulation and monitoring blood sugar levels. Detection tests are also available for numerous conditions from venereal disease and urinary tract infections to colorectal cancer, menopause, and hypertension.

There was a fair amount of self-diagnosis being practiced even before there were hospitals. Ancient Egyptian societies used papyrus and eucalyptus leaves for diagnosis. To determine whether or not they were pregnant, Egyptian women smeared eucalyptus oil on their arms and breasts before they retired in the evening. If their skin had a greenish tinge in the morning, they were confident that they were pregnant. Another pregnancy test entailed urinating on the leaves of a papyrus plant. If the plant died, the test was negative; if it lived, they began to make plans for motherhood. There does not seem to be any record of how accurate these tests were, but they were interesting nonetheless!

The contemporary movement toward increased self-diagnosis has been stimulated by several distinct social and technological changes. The first reason relates to lifestyle and a trend toward "wellness." Generally speaking, people have become more health and fitness conscious. Along with the emergence of several new journal/magazine titles, jogging, aerobics classes, and nutrition awareness (commonly labeled the "health food craze"), it seemed people began to take much more interest in their own medical care. Some exhibited an almost insatiable desire to know more about how their bodies functioned. Subsequently, many of us learned about resting heart rates, lean body weight, metabolic rates, various muscle groups, and the importance of personalized exercise regimens. It is probably safe to assume that the average person who you might have approached in a 1960's grocery store would not be able to tell you much about his or her optimal target heart rate zone! The availability of diagnostic kits for at-home use fit perfectly into society's newfound interests in its physical well-being.

Another reason for the increased use of these products involves the soaring costs of medical treatment. Getting sick or suspecting a medical problem used to mean a trip to the doctor's office. These visits were often accompanied by a lengthy wait for laboratory test results. The evolution of the test-kit industry is providing people who may be ill with a different set of options, often at considerable cost savings. For instance, for approximately $10, a person can purchase a detection test kit to determine the presence of blood in the feces.

According to the American Cancer Society, occult (hidden) blood in the stool may be an early indication of colorectal cancer. Some persons believe it is no longer cost effective to pay for a rectal exam with a physician unless this type of self-test is positive.

A third development which has strengthened the growth of the self-diagnosis movement involves a series of successful technology research and development projects. As computer chips have become less expensive and more miniaturized, self-diagnostic kits have become more accurate and easier to use. The development of monoclonal antibodies (MAbs) has also contributed to the substantial increase in the accuracy of the tests performed at home.

As you may recall from Chapter 2, **monoclonal antibodies** are hybrid cells that are created through genetic engineering techniques. These monoclonals have the potential to "recognize" a particular chemical structure. They can therefore act as sensitive probes for illnesses or physical conditions from pregnancy to cancer. For example, the over-the-counter pregnancy tests that were first marketed in the late 1970s were found to be 75% reliable. They did not make use of MAb technology. Pregnancy test kits that became available during the mid-1980s were shown, on the average, to be 95% reliable—hence a substantial increase in accuracy due to this technological breakthrough.

Taking a "birds-eye view" of the drug store shelves, there appear to be three categories of self-testing products. The first group is used to help diagnose a condition or disease in people who possess given symptoms. The most common example here is the pregnancy test kit which is normally used after a woman misses a period. The second type includes screening tests that identify indications of diseases in persons without symptoms. Tests designed to detect hidden (occult) fecal blood fall into this category. A third classification is monitoring devices to provide continual check-ups on an existing condition. These are often purchased under the advice of a physician. Good examples of this product are kits used by diabetics to measure the level of glucose in their blood and those used by women to determine when they are ovulating. All tests that examine body specimens such as blood, urine, saliva, and so forth are called in vitro tests. Figure 6.7 illustrates several typical self-diagnostic products available without a prescription.

An unfortunate situation may arise if users translate "self-test" to mean "self-diagnosis." Essentially, some of these test kits could shift the diagnosis of disease from the doctor's office to the home medicine cabinet. This may be construed as a quiet revolution in health care which has received mixed reviews from practicing physicians.

Some health professionals believe properly administered self-tests show great potential for improving public health, as long as they are performed in conjunction with medical guidance. Home diagnostic testing devices are most valuable when they plug major gaps in current medical care. In other words, people who are concerned enough to take the first step and spend $10 or so on a test kit may be equally concerned to follow up and make an appointment to see their doctor. There is a significant benefit procured when the results

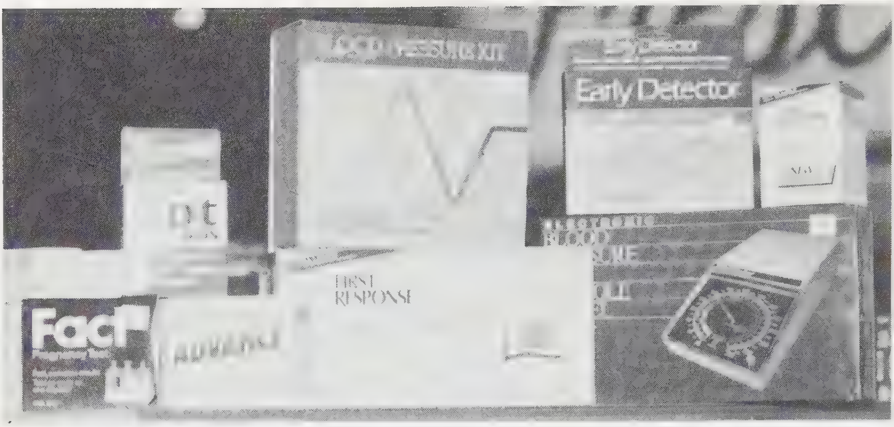

Figure 6.7 Several of the self-diagnostic products and kits that are available over the counter without a prescription at your local drug store. (Michael Dafferner)

of an off-the-shelf test prompts a person to get necessary medical care earlier than would have occurred without the test. Furthermore, there is certainly the possibility for more effective treatment when a doctor can say to the patient, "Here is an explanation of your condition—I would like you to go home and test yourself periodically with this test kit and report the results back to me in three weeks."

On the down side, other physicians feel quite uneasy about this self-test health phenomenon. Some fear patients may substitute the kits for a doctor's opinion. Diagnosis by a physician normally involves an evaluation of the patient's medical history, a physical examination, a series of tests, and possible consultation with other medical experts. Another concern expressed involves the fact that persons may only test for one disease without knowing the same symptom could be signaling an even more serious malady.

There is also the chance kit users may not perform the test correctly or misinterpret the results attained. When this happens, the patient receives what are called "false positives" or "false negatives." For instance, a woman may perform a test for pregnancy and conclude that she is not pregnant, only to find out three or four weeks later via a doctor's examination that she is pregnant (false negative). You can well imagine the severity of this type of event if the woman had, for example, ingested some form of prescription drug not recommended for use during pregnancy. Similarly, a "false positive" result in this case may cause premature elation or even unnecessary anxiety. Other causes for concern involve the shelf-life of the test kit and its estimated reliability.

In any event, self-test kits are probably here to stay. We can most likely expect further research and development pursuits to improve the existing products and to also expand the market considerably. The Food and Drug Administration's (FDA) Center for Devices and Radiological Health regulates medical devices. It requires that devices developed for use by a lay person comply with the same regulations to ensure safety and effectiveness as the devices used in professional laboratories.

While this sounds reassuring in print, self-tests present several variables that are not as evident in the professional sector. For one thing, professional labs are designed, managed, and maintained specifically for scientific testing. Although medical labs are not infallible, their test results are generally more reliable and uniform since they are acquired in a controlled environment (proper lighting, chemical storage requirements, sanitary conditions, instrument maintenance, etc.). Another factor stems from the fact most laboratory technicians have had formal training and experience which have enabled them to develop expertise in conducting the tests. When we purchase a test-kit, most of us must rely entirely on the written instructions and/or diagrams provided inside the package.

The FDA has subsequently attempted to upgrade its guidelines for evaluating the safety and effectiveness of self-testing kits and devices. Some of the general precautions they recommend are listed below.[4] Recognize that all guidelines do not necessarily apply to all tests on the market.

General FDA Guidelines for Using Self-Test Kits

1. For test kits that contain chemicals, note the expiration date. Beyond that date, chemicals may lose potency and affect results. Don't buy or use a test kit if the date is past.
2. Consider whether the product needs protection from heat or cold. If so, don't leave it in the trunk of your car or next to a sunny window on the trip home. At home, follow storage directions.
3. Study the package insert. First, read it through to get a general idea of what the test is about. Then, go back and really study the instructions and pictures until you fully understand each step.
4. If something is not clear, don't guess: Consult a pharmacist or other health professional. Or check the insert for a toll-free "800" number to call.
5. Learn what the test is intended to do and what its limitations are. Remember: The tests are not 100 percent accurate.
6. If color is a part of the test and you are colorblind, be sure someone who can discern color interprets the results for you.
7. Note special precautions, such as avoiding physical activity or certain foods and drugs before testing.
8. Follow instructions exactly, including the specimen collection process, if that is a part of the test. Sequence is important. Don't skip a step—for instance, if a step to validate the test or calibrate the instrument is included, do it.
9. When collecting a urine specimen, unless you use a container from a kit, wash the container thoroughly and rinse out all soap traces, preferably with distilled water, which is generally purer than tap or bottled water.

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[4] See Farley, Dixie. Do-it-yourself medical testing. *FDA Consumer*, February 1986, *20*(1), pp. 22-28.

10. When a step is timed, be precise. Use a stopwatch or at least a watch with a second hand.
11. Note what you should do if the results are positive, negative, or unclear.
12. Keep an accurate record of the results.
13. As with all medications, keep test kits that contain chemicals out of the reach of children. Promptly discard used test materials as directed.
14. Report any malfunction of a self-test to the manufacturer or to the FDA directly. When you make the report, be sure all pertinent information is accessible (product name, serial and lot numbers, dosage strength, expiration date, date of use, details of the problem, etc.).

In summation, the use of self-diagnostic test kits in our society is likely to increase. When used correctly, they can offer many health benefits. With this in mind, it is critical people be educated to use test-kits and other diagnostic tools in an effective, safe, and confident manner.

SUMMARY

Technology has had a positive influence on the practice of medicine in our society. Amidst an impressive array of computer-assisted diagnostics and life sustaining pharmaceuticals and devices, the cost of health care remains an urgent matter of international concern. The advent of diagnosis related groups (DRGs) and health maintenance organizations is evidence that some progress is being made toward solving this problem.

Current demographic figures indicate the average life expectancy for American men and women has surpassed the 70-year mark and is rapidly approaching 80. Recent technological breakthroughs in the medical field have played a major role in this development. A review of several feats in noninvasive surgery and the use of technology to enable infertile couples to bear children have been described in this chapter. These areas of specialization were selected to illustrate that science and technology in medicine are here to stay—there may be no turning back. A cost/benefit analysis of these revolutionary techniques must emerge to continually assess social ethics and the moral responsibilities of our physicians.

Several factors have stimulated a definite trend toward self-diagnosis in the United States. A diversified collection of self-diagnostic test kits and medical devices have become available on the shelves of local drug stores. They have been met with mixed reactions among practicing physicians.

The greatest challenge for contemporary and future health care professionals will revolve around:

1. Curtailing the rampant increase in the cost of medical care.
2. The appropriate and efficient use of medical technology.
3. Preservation of social ethics.
4. A modification of medical procedures integral to the trend toward self-diagnosis.

DISCUSSION QUESTIONS

1. With reference to the cost of health care, explain what is meant by the phrase: Conventional financing plans and governmental policies have stimulated the use of technology at any cost.
2. Identify the primary features that characterize a modern health maintenance organization (HMO). Provide a specific example of an HMO in your area and retrieve a copy of an information brochure from them if possible. Be ready to present your findings during an upcoming class discussion exercise.
3. How does the relationship among the following three variables present a "cyclical" problem for the health care industry?
   TECHNOLOGY
   HUMAN NEED
   MEDICAL COSTS
4. Explain what is meant by the term noninvasive surgery. How does this type of medical treatment differ from a conventional surgical procedure? Provide at least three contemporary examples in your explanation.
5. Do you feel that today's medical professionals are overly dependent on technology? Give reasons to support your position. What effect does the use of technology have on ethical standards in society?
6. What are the three categories into which most self-diagnostic products can be classified? Make a trip to your local drugstore to take a survey of the self-diagnostic kits available without a prescription. Provide a detailed description of the function and usage of at least one of the products located.

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Chapter 7

MANUFACTURING AND PRODUCTION DEVELOPMENTS

DATELINE

Cincinnati, Ohio

Researchers at the Center for Robotics Research at the University of Cincinnati believe that the first practical domestic robot may be a lawnmower. They have been developing a functional robotic lawnmower for several years. Since it has been reported that more than 50,000 Americans are injured each year while working with their lawnmowers, their emphasis has been on safety and manufacturer liability. Envisioning a robot lawnmower that operates a safe distance away from humans, they conclude that people will be separated from the source of the danger.

A variety of hardware and software developments have already been made. Safety devices including a warning light and bumper can stop the machine if it encounters an object. Sonar detectors can locate stationary and moving objects. An omnidirectional vision system enables the mower to avoid obstacles and monitor progress while cutting the lawn. A computer program that models the region-filling strategy a robot mower employs can ensure that it efficiently cuts all areas of an irregularly shaped lawn. Researchers are convinced that a marketable product can be realized in a few years if funds remain available to implement some sophisticated changes into their current prototype . . . .

INTRODUCTION

For much of the 20th century, the United States was a world leader in manufacturing. Suddenly, as we approach the 21st century, the nation is faced with the challenge of rebuilding its factories and retooling its production lines. The area of the country that used to be called the "Steel Belt," once labeled the "Rust Bucket," is now being applauded as America's "Automation Alley."

Industrialists, venture capitalists, economists, and others have continually made projections regarding the rebirth of American manufacturing prowess. Some of their ideas have come to fruition – others have not. Many speak of the decline of America's manufacturing base, while others applaud the future successes for those industries that have aligned themselves with leading edge technologies.

In either case, American companies have been confronted with a dramatic increase in foreign competition over the past decade. Refusing to die quietly, they have fought back in many different ways. Shoe manufacturers have screamed for tariffs. In an attempt to match foreign competitors' low labor costs, garment makers and electronic components companies have moved their operations offshore. Several domestic consumer electronics companies have actually stopped making television sets and videocassette recorders. Rather, they have turned themselves into marketing and distributing organizations for products that are made outside the United States.

Amidst the confusion, there are a number of companies who are responding quite differently to the new global economy. Instead of seeking shelter behind protective tariffs, they are investigating and developing new technological solutions to their present crises. Essentially, they are doing whatever is necessary to meet the competition head-on. Manufacturing is the center stage attraction and has earned a renewed sense of importance among technical managers nationwide. One of the more visible examples of a company with a new approach to production is General Motors Corporation. By the mid-1980s, GM had invested in several computer-vision companies and had already begun its campaign to establish a common computer language for the factory floor.

It soon became apparent to several other industrial firms that the entire area of manufacturing engineering had earned a very high level of respectability. Along the way, a whole new descriptive vocabulary appeared on the scene. Although most technical disciplines usually have their own jargon of sorts, the array of acronyms affiliated with the manufacturing industry is enormous! In order to gain a basic understanding of the developments taking place in production operations, one must feel comfortable with terms like MRP, MAP, JIT, OPT, TOP, FMS, CAD, and CIM. And this is just a partial list! Persons who are presently employed in manufacturing management positions are being asked to evaluate or implement a vast array of new systems to improve production efficiency.

In one way or another, each of these new manufacturing systems challenges traditional assumptions and contemporary production procedures. These innovative methods are not only completely changing our manufacturing processes, but are also having a significant impact on operations management.

MRP is an abbreviation for **materials requirements planning**. MRP allows for a considerable degree of advance planning for medium-inventory, mass production companies. Adoption of this strategy, however, may be detrimental to flexibility and an informal working environment.

The Japanese use the term Kanban to refer to a manufacturing strategy called **just-in-time** or JIT. The core objective of JIT is to obtain low-cost, high quality, on-time production by minimizing instances of idle equipment, facilities, or workers. JIT keeps inventory costs down but also demands well structured supply lines and very cooperative employees.

OPT is short for **optimized production technology**. This operation system focuses on clearing up bottlenecks in the manufacturing process. It is a proprietary computer software package that calculates the near-optimum schedule and sequence of operations for all of a manufacturing firm's work centers. OPT enthusiasts claim it can simultaneously maximize the use of critical resources and minimize work-in-process inventories. This translates to higher plant output and shorter throughput spans.

This chapter provides an overview of these and other developments in manufacturing technology. You will need to read further to learn the meanings of the other production operation "techno-terms" listed above. Manufacturing managerial decisions are presently shaping the profile of tomorrow's factories. The implementation of automated systems will most likely have a visible impact on the United States lead in production, as well as on the credentials of its present and future work force.

Quality assurance (QA) strategies are also in the forefront of operations planning. New and improved materials are being introduced on a regular basis. Selecting the most effective manufacturing system takes time and implementation costs are exorbitant. Those companies which make systematic and informed choices will be the ones who emerge as tomorrow's manufacturing leaders. They will most probably be the ones who contribute to the global market with a host of functional products "Made in America."

1. Will **computer integrated manufacturing** (CIM) and all of its related technologies provide today's corporations with an avenue for change and progress?
2. Why have some corporations been reluctant to enthusiastically support computer integrated manufacturing (CIM) strategies?
3. How do present-day workers respond to the presence of robots in their work environment and on the shop floor?
4. Are we approaching the day when all factories will be run automatically without any human intervention?
5. What "new" production operations have been recently assessed by manufacturing engineers? In which disciplines do they show promising applications?
6. When did American manufacturers first begin to realize that quality assurance was an essential managerial objective? Why did this occur?

KEY CONCEPTS

As you review the material contained in this chapter, you should learn the meaning of each of the following technical terms and phrases. Be especially attentive to the numerous manufacturing acronyms as they are mentioned initially in the discussion.

Flexible Manufacturing Systems (FMS)
Computer Integrated Manufacturing (CIM)
Manufacturing Automation Protocol (MAP)
Statistical Process Control (SPC)
Materials Requirements Planning (MRP)
Global Economy
Industrial Robot
Group Technology (GT)
Just-in-Time (JIT)
Quality Assurance (QA)
Bar Coding

COMPUTER INTEGRATED MANUFACTURING TECHNOLOGIES

While attempting to make sense out of all the recently introduced manufacturing "buzzwords," one is probably inclined to wonder which of them is the most generic. In other words, if industrialists set out to develop a hierarchy of the numerous technologies that somehow make a contribution to manufacturing and production operations, which one would end up on top? Due to the nature of the changes taking place in this discipline, it is difficult to imagine that a descriptive flow chart of this type would be accurate for very long. New procedures coupled with novel managerial strategies continually give way to an assortment of new terms. As soon as you begin to feel comfortable with current terminology, another new acronym appears in the literature.

Industry's ongoing search for strategic flexibility and the desire to automate production follows many different technological pathways. A comprehensive review of technical reports and business commentaries indicates that they all come together under the umbrella term of CIM, **computer integrated manufacturing**. In the broadest sense, CIM (pronounced "sim") encompasses all of the manufacturing technologies available today, including: computer-aided design (CAD), group technology (GT), computer-aided manufacturing (CAM), automated materials handling (AMH), robotics, manufacturing planning and control software (MPCS), total quality control (TQC), and a lot more. The illustration presented in Figure 7.1 reveals the central position of CIM. It can be regarded as a unifying force among the three basic functional areas of any industrial enterprise—namely, design, production, and management.

In actuality, CIM is *not* a specific technology that can be purchased one week and installed during the next one. Even though CIM is exchanged back and forth as a technical buzzword, it is not as much a technology as it is a philosophy of operation.

The first word in CIM—"computer"—is somewhat misleading in that it suggests that computer technology *does* the integrating. In practice, management is the central integrating force and the computer is a tool for execution. The integrating process requires well-thought-through managerial goals. CIM adoptions and subsequent implementations are like snowflakes; proverbially, no two are the same. For this reason, company-specific planning is imperative. Manufacturing managers and engineers do not have the option of calling up their local vendor to place an order for a turnkey CIM package.

If we can reach some measure of agreement regarding which building block

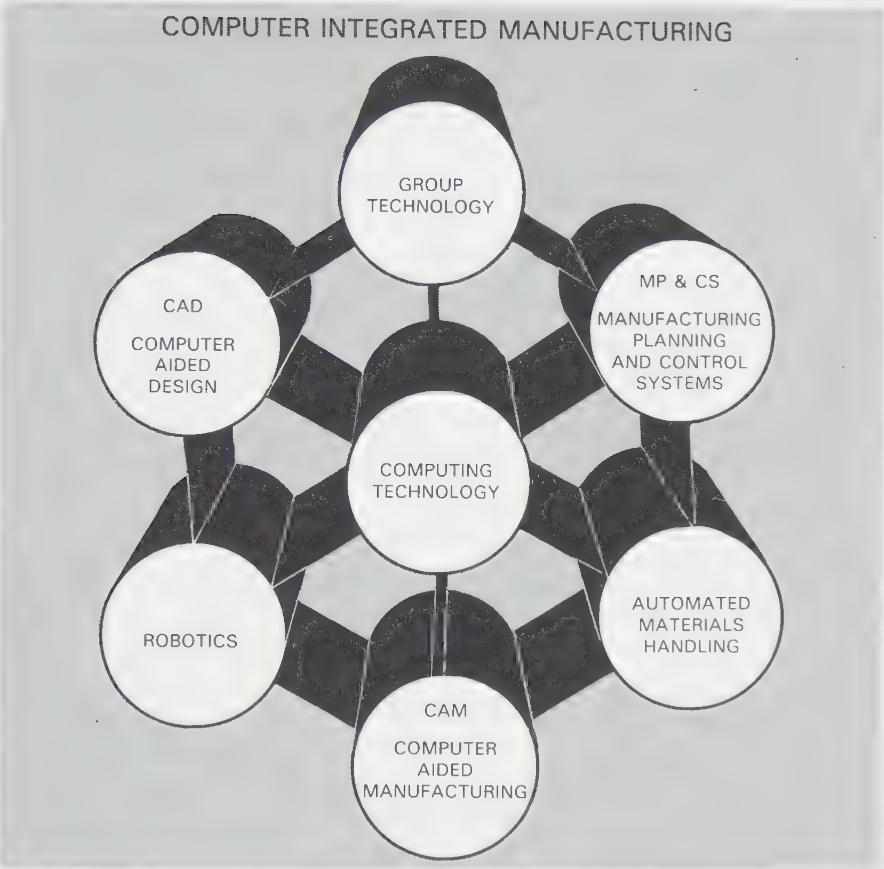

COMPUTER INTEGRATED MANUFACTURING
GROUP TECHNOLOGY
CAD
COMPUTER AIDED DESIGN
MP & CS
MANUFACTURING PLANNING AND CONTROL SYSTEMS
COMPUTING TECHNOLOGY
ROBOTICS
AUTOMATED MATERIALS HANDLING
CAM
COMPUTER AIDED MANUFACTURING

Figure 7.1 Diagram showing CIM and its relationship to other systems within an industrial enterprise. (Gunn. The CIM connection)

technologies make CIM possible, a general sketch of its potential can be drawn. Figure 7.2 provides one perspective via a logical diagram that identifies several foundational components of computer integrated manufacturing. This technological framework reveals the need for critical integration among all parts of a manufacturing enterprise. Basic to an effective CIM strategy is a strong commitment to intercompany communication. Successful implementations require a spirit of cooperation and understanding from the highest level of management on down, combined with employee readiness to accept new technology.

A successful CIM operation makes it possible for the computer systems used by management, design, and manufacturing personnel to communicate with one another. CIM allows in-plant design systems to obtain data from management on the current cost of raw materials and also from manufacturing regarding ways to adapt designs for more efficient production. Likewise,

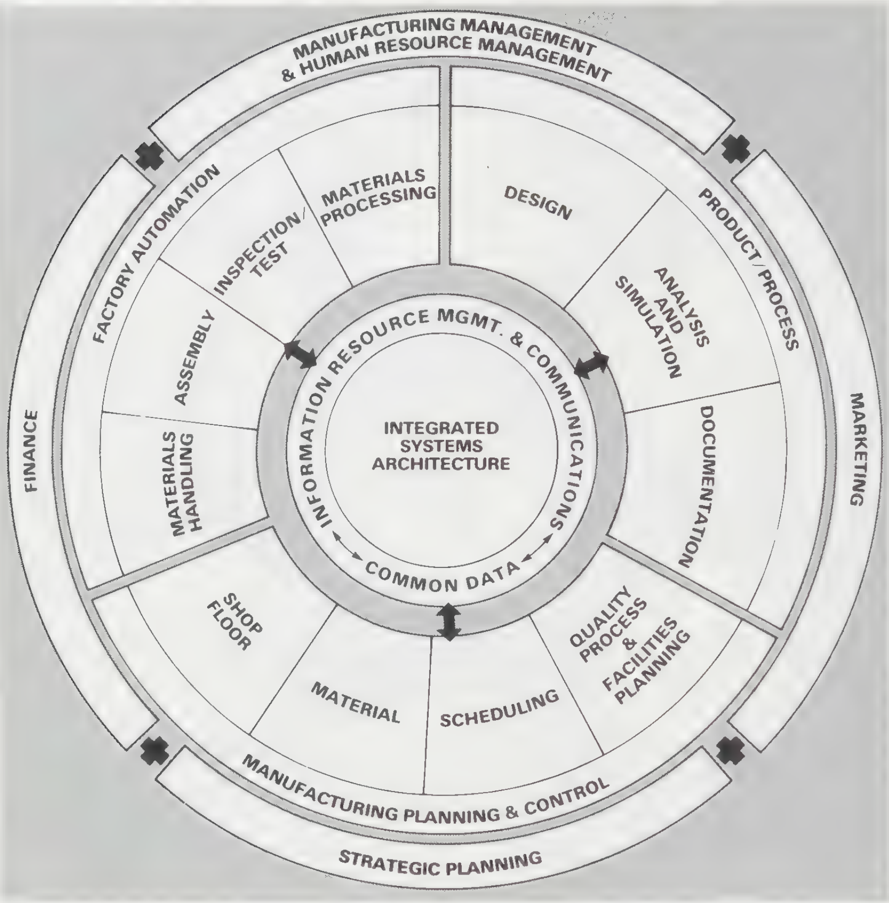

MANUFACTURING MANAGEMENT & HUMAN RESOURCE MANAGEMENT
FACTORY AUTOMATION
MATERIALS PROCESSING
INSPECTION/TEST
ASSEMBLY
MATERIALS HANDLING
DESIGN
PRODUCT/PROCESS
ANALYSIS AND SIMULATION
DOCUMENTATION
MARKETING
FINANCE
INFORMATION RESOURCE MGMT. & COMMUNICATIONS
INTEGRATED SYSTEMS ARCHITECTURE
COMMON DATA
SHOP FLOOR
MATERIAL
SCHEDULING
QUALITY PROCESS & FACILITIES PLANNING
MANUFACTURING PLANNING & CONTROL
STRATEGIC PLANNING

Figure 7.2 Symbol prepared by Society of Manufacturing Engineers that depicts critical CIM links.
(Technical Council of the Computer and Automated Systems Association of SME)

manufacturing systems on the factory floor have direct access to design data in order to more effectively plan the steps for making products. Finally, managers at all levels can use their computers to acquire up-to-date (real time) information from both design and manufacturing data bases. Ostensibly, this feature of CIM allows for maximum coordination and centralized control of industrial operations. Computers are used throughout the company to:

☐ Provide design assistance.
☐ Translate specifications into drawings, parts lists, and routings.
☐ Schedule work.
☐ Control machine tools.
☐ Provide vital information for management.
☐ Execute routine clerical tasks.

There are several advantages to a systematic integration among the design, manufacturing, and administrative functions within a manufacturing facility. First, there may be a reduction in the duplication of data entry concerning product specifications, tolerances, order quantities, inventory levels, raw materials, and so forth. This feature alone could result in lower labor costs.

Second, there should be fewer discrepancies in the data which often occur when a number of persons gather information from different sources at different times during the production cycle. For instance, the product designer uses one set of raw materials costs while the manufacturing group refers to a totally different set to make strategic decisions. CIM makes this scenario more the exception than the rule.

A third benefit CIM provides is the reduction in cycle times. Prototypes can be prepared and tested more quickly. Engineering specifications can be translated into the finished product with fewer delays. More precise information on job status at any given point in time can result in more accurate delivery estimates for the firm's customers.

Other tangible benefits that have been reported among CIM users include: lower inventory; less scrap and rework; fewer engineering prototypes; reduced changeover costs; lower energy bills; and the elimination of data re-entry and processing duplicates. Manufacturing managers seem to obtain further incentive to implement CIM when they begin to ponder a series of intangibles such as: better quality control; higher competitive standing; faster product introduction; consistent and tireless operation; and increased flexibility in design, product mix, production volumes and process routings. Regardless of the rewards that are both real and imagined, corporate survival appears to be the number one reason for implementing CIM.

Most manufacturers recognize the need to automate and improve their productivity in order to stay in business. To remain competitive, they must formulate ways to get new products into the marketplace at a faster rate. A series of CIM technologies, such as those mentioned earlier, may ultimately be the answer. It is not within the scope of this chapter to present a detailed examination of any particular manufacturing technology. Instead, the following paragraphs provide a brief discussion of a few of the flagship manufacturing and business strategies that will inevitably be responsible for the transformation of today's shop floors into tomorrow's automated factories.

GROUP TECHNOLOGY(GT)

Group technology (GT) has drawn an increasing amount of interest from manufacturers because of its great potential for boosting productivity. GT is an approach to manufacturing which seeks to maximize production efficiencies by grouping together similar and recurring problems and/or tasks. A key feature of GT is the segregation of parts according to their design or manufacturing characteristics. When similar parts are grouped together, each collection can ultimately share set-ups and machine tools, thus reducing production costs.

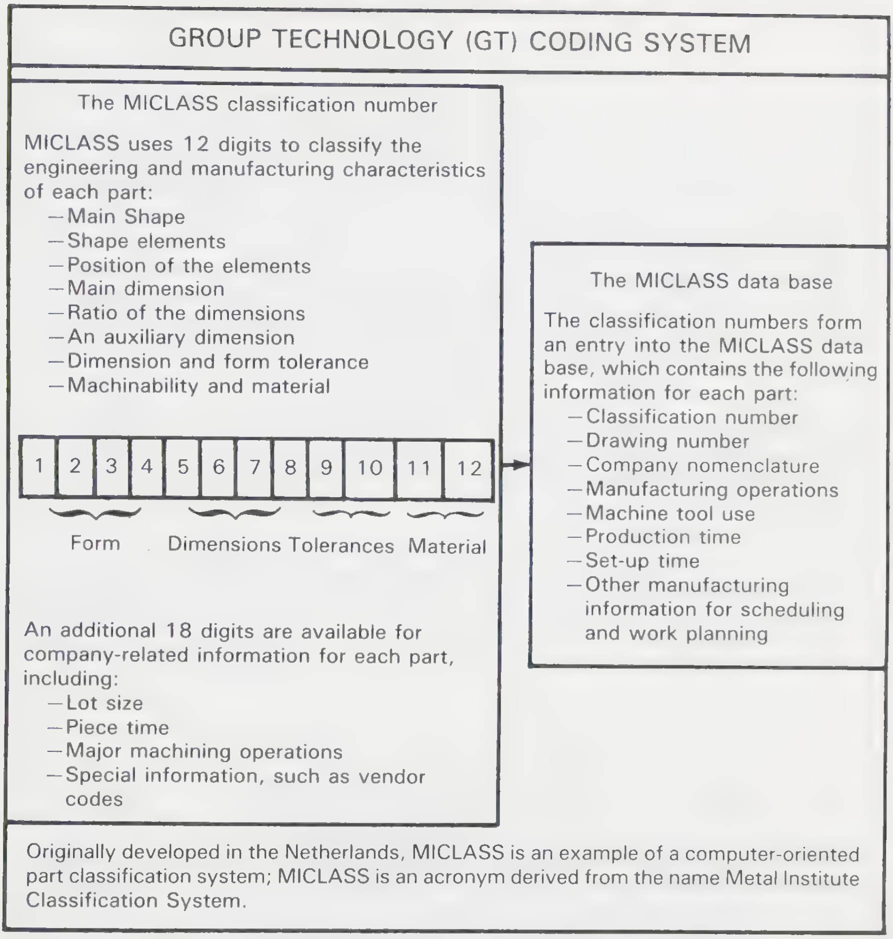
This approach is an improvement over typical or traditional batch processing methods. Experts estimate that batch manufacturing is still prevalent in over 75% of firms. In most cases, parts cannot flow smoothly through the process since different parts usually require different set-ups or must be transferred to another machine. The application of computers in the early 1970s made it feasible for companies to identify and track the thousands of parts being produced through the use of group technology software. Engineers found that they could also use GT systems to determine whether an existing part could obviate (make necessary) the need to design a new one.

Basically, a GT data base is a computerized filing system that speeds up the retrieval of parts information, facilitates the design process, and enhances the communication between individual functional areas inside the plant. GT systems also improve the accuracy of process planning and aid in the creation and operation of manufacturing cells. Manufacturing technology experts note that it generally costs between $2000 and $12,000 to design and prepare a new jig or fixture for manufacturing. Therefore, the elimination of design duplication can yield significant economic benefits. Above and beyond savings in design retrieval and manufacturing, GT is an important building block for CIM. A group technology data base can contain detailed information about the parts a company produces, the equipment available to produce those parts, and the best methods to complete the job as scheduled. GT has also been credited for: reduced materials handling costs; reduced production planning and control efforts; reduced need for floor space; reduced design effort and easier design retrieval; more accurate cost estimates; and improved quality.

In design engineering, parts can be classified by geometric similarities through the use of codes that contain design attributes. For instance, the objective could be to retrieve all rotational parts with a length-to-diameter ratio of less than 2. Using the GT code, it is easier to locate one that fits the current needs at hand and the engineering department can avoid designing a brand new part. As a rule, GT codes are assigned to purchased items and fabricated parts.

The greatest potential of GT is realized via this formal coding system in which each part receives a numeric or alphanumeric code that describes specific characteristics. To be most useful, the code should be able to describe the part from both a design *and* a manufacturing perspective. Such features as the external and internal shapes, dimensions, threads, grooves, and splines serve to describe the geometric form (design). The shape and chemistry of the raw material, the surface finish, various tolerance requirements, and the possible need for heat treatment are examples of manufacturing specifications. It is easy to imagine a code with a large number of characters if one tries to capture all significant attributes. Figure 7.3 provides one example of a GT coding system called MICLASS. It was originally developed in the Netherlands. The abbreviation is derived from the name Metal Institute Classification System. Once the parts have been coded, they are further classified into families.

The most basic form of GT in a job shop setting involves the sequencing of similar parts on a machine. A more sophisticated application entails the



GROUP TECHNOLOGY (GT) CODING SYSTEM

The MICLASS classification number

MICLASS uses 12 digits to classify the engineering and manufacturing characteristics of each part:
- Main Shape
- Shape elements
- Position of the elements
- Main dimension
- Ratio of the dimensions
- An auxiliary dimension
- Dimension and form tolerance
- Machinability and material

An additional 18 digits are available for company-related information for each part, including:
- Lot size
- Piece time
- Major machining operations
- Special information, such as vendor codes

The MICLASS data base

The classification numbers form an entry into the MICLASS data base, which contains the following information for each part:
- Classification number
- Drawing number
- Company nomenclature
- Manufacturing operations
- Machine tool use
- Production time
- Set-up time
- Other manufacturing information for scheduling and work planning

Originally developed in the Netherlands, MICLASS is an example of a computer-oriented part classification system; MICLASS is an acronym derived from the name Metal Institute Classification System.

Figure 7.3 MICLASS Coding System used in some group technology programs.

creation of families (using the GT code) and then dedicating certain machines for the exclusive processing of these families. The most advanced GT application to date is through the creation of manufacturing cells. A cell is a collection of machine tools and materials-handling equipment grouped together to process one or several part families.

The advantages of cellular manufacturing are most significant when the cells are designed to handle one dominant materials flow. A fixed conveyor system is used to connect the work stations within the cell. Essentially, a cell is a hybrid production system. It is a blend of a job shop that produces a large variety of parts and a flow shop that is dedicated to the mass production of one product. Figure 7.4 shows the difference between manufacturing parts in a job shop that uses a conventional layout and a cell shop that subscribes to GT principles.

MOVEMENT OF PARTS THROUGH A JOB SHOP AND A CELL SHOP

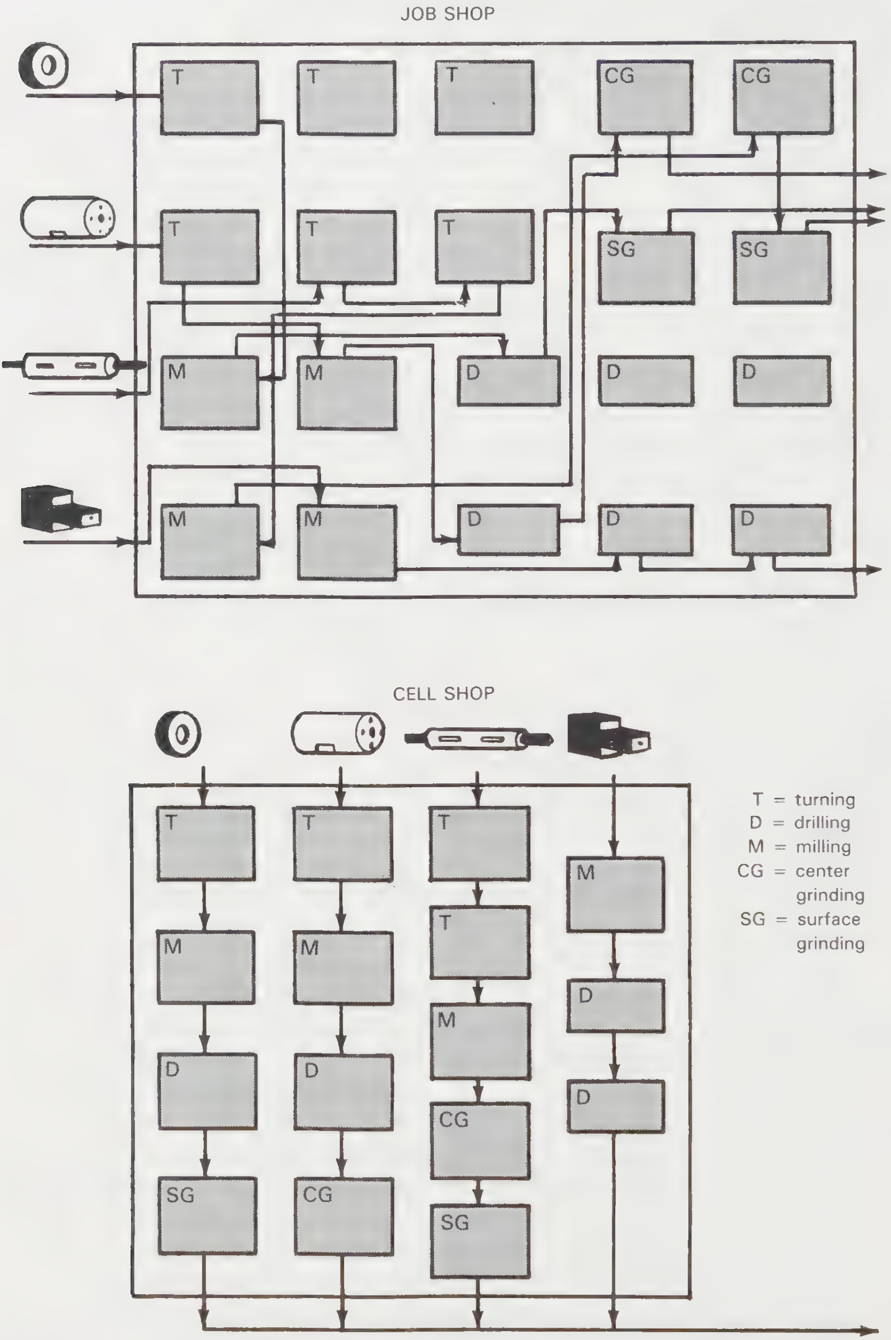

JOB SHOP
T
T
T
CG
CG
T
T
T
SG
SG
M
M
D
D
D
M
M
D
D
D
CELL SHOP
T
T
T
M
M
M
T
D
D
M
D
CG
D
SG
CG
SG
T = turning
D = drilling
M = milling
CG = center grinding
SG = surface grinding

Figure 7.4 Simple drawing to illustrate movement of parts through a traditional job shop and a GT-oriented cell shop.

JUST-IN-TIME (JIT) PHILOSOPHY

"Just-in-Time" (JIT) attempts to reduce work in process (sometimes abbreviated WIP) to an absolute minimum. Specifically, JIT measures its acceptable WIP levels in hours or minutes (the traditional North American approach measures acceptable WIP levels in days, weeks, and sometimes even months of production). The system constantly seeks to reduce lead times, work-in-process inventories, and set up times. JIT is the label associated with the Japanese manufacturing philosophy that is most notably embodied in the Toyota production facilities. It is also referred to as "kanban."

Within the JIT system, production processes are viewed as the only means of adding value to the product being manufactured. The indirect tasks of transportation, inspection, and storage are defined as "wastes" that should be eliminated wherever possible. JIT focuses on achieving closely-coupled, highly consistent, short cycle processes that require a minimal work in process inventory. This approach deviates from conventional systems where the emphasis has been on automating indirect operations rather than eliminating them. In many instances, manufacturing managers eventually find themselves trying to coordinate efforts among the resultant "islands of automation" and discover a lack of continuity in the flow of materials between production processes. See Figure 7.5.

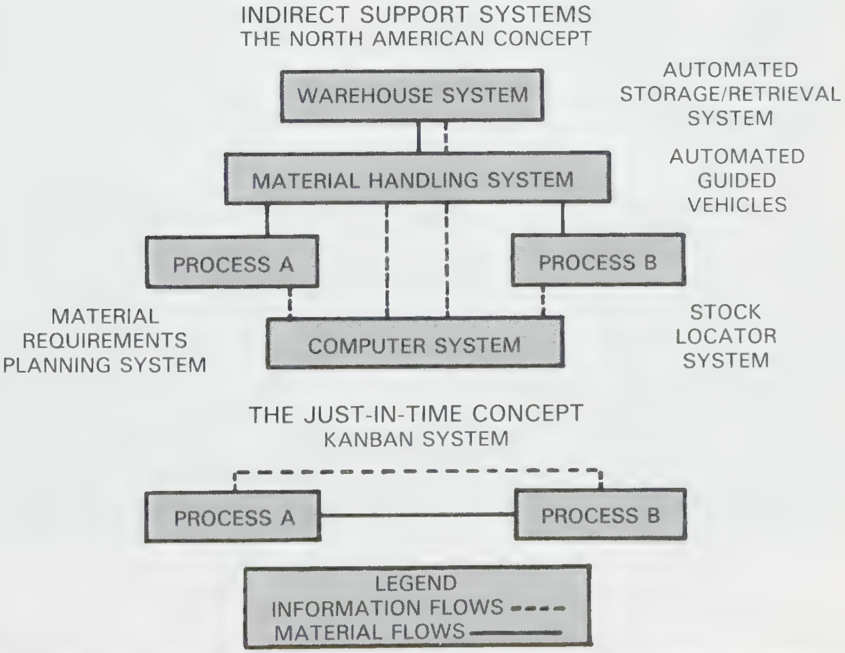

INDIRECT SUPPORT SYSTEMS
THE NORTH AMERICAN CONCEPT
WAREHOUSE SYSTEM
AUTOMATED STORAGE/RETRIEVAL SYSTEM
MATERIAL HANDLING SYSTEM
AUTOMATED GUIDED VEHICLES
PROCESS A
PROCESS B
MATERIAL REQUIREMENTS PLANNING SYSTEM
COMPUTER SYSTEM
STOCK LOCATOR SYSTEM
THE JUST-IN-TIME CONCEPT
KANBAN SYSTEM
PROCESS A
PROCESS B
LEGEND
INFORMATION FLOWS ----
MATERIAL FLOWS ——

Figure 7.5 Flow diagram which differentiates between JIT concept and traditional North American concept of manufacturing.

JIT presupposes that the production rate at the final assembly line is even. Any revision in the monthly master production schedule, such as those that might be needed to accommodate changes in the market, must be small. JIT also mandates that the daily schedule for each part or assembly remain nearly the same every day. This distinction keeps the set up times and associated costs at negligible levels. External to the JIT plant, the company's suppliers are expected to act like extended storage facilities of the company itself. The hallmark of JIT purchasing seems to involve the steady purchase of parts in small lot sizes (just-in-time for use on the line), as opposed to the periodic acquisition of large batches which was traditional.

Through the mid-1980s, JIT had been used for mass-produced items in Japan and Europe, and had started to gain momentum in North America. An item called the kanban move ticket, illustrated in Figure 7.6, is used instead of the job orders and routing sheets of the past. It emphasizes small lot sizes. A chain of these move tickets connects all production stages from the firm's suppliers to its retailers. For this reason, no additional paperwork is needed to coordinate planning and control operations. JIT is a "pull system" where the user department pulls the part of subassemblies from the supplier departments. No extra production or inventories are permitted. JIT systems reportedly cannot tolerate load fluctuations of more than plus or minus 10 percent.

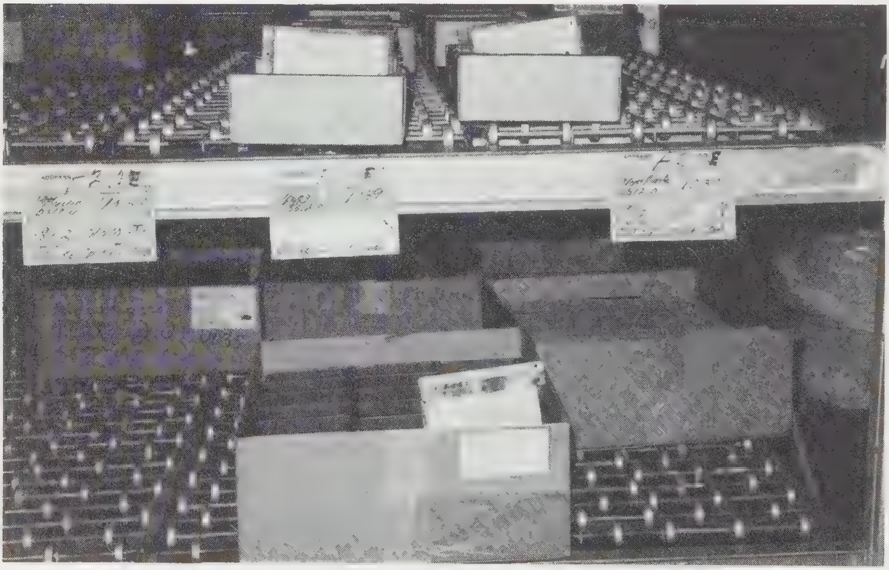


Figure 7.6 New United Motor Manufacturing, Inc. (NUMMI) is an example of a cooperative effort between the United States and Japan. It manufactures automobiles in this country. Their use of kanban move tickets such as those shown here is one essential ingredient in Just-in-Time production. A typical kanban card will contain the following information: Part Number/Name, Quantity, Previous Operation, Production Routing & Schedule, etc.

Most companies which have adopted the JIT philosophy also have established quality circles among their work forces. These groups are given the opportunity to make useful improvements in the company's operations. They work to cut down on lot sizes and reduce lead and set up times. They often help to solve vendor problems and minimize scrap losses.

Japanese companies that have used kanban for five or more years reported close to a 30 percent increase in labor productivity, a 60 percent reduction in inventories, a 90 percent reduction in quality rejection rates, and a 15 percent reduction in necessary plant space. General Motors implemented the JIT strategy in the early 1980s. Within a few years, GM reduced its annual inventory-related expenses from $8 to $2 billion! Appliance makers including General Electric, Westinghouse, and RCA have also begun to experiment with the JIT manufacturing/purchasing philosophy in some of their plants. At this point, none of them has achieved an ideal system comparable to Toyota. On the other hand, most have reported some measure of success in reducing their inventories and production lead times. The major problems they have encountered along the way were related to faraway suppliers, poor quality of parts, unreliable freight systems, and resistance from employees.

CAD/CAM INTEGRATION

Prior to the 1960s, the design engineer's primary tools included a slide rule, mechanical calculator, and drawing board. Advancements in interactive computer graphics enabled corporations like General Motors and Boeing to start automating the design process through the use of expensive mainframe computers. By the 1970s, the technology had trickled down to less costly minicomputers and the "CAD/CAM" industry became a reality.

With the term CAD/CAM came a variety of technical interpretations and definitions. One explanation which is both logical and understandable suggests the following: "CAD/CAM is simply a general name or umbrella term for the many ways the computer can be used as a tool to help design, make and sell all kinds of products. More specifically, CAD/CAM implies the automation of this process."[1]

The early days of computer-aided design (CAD) and computer-aided manufacturing (CAM) saw stand-alone, independent systems that handled specific functions. In many instances, the head of product design took responsibility for the CAD devices while the plant manager monitored the CAM machines. Simultaneously in the front office, an administrative officer could be found making arrangements for routine activities like order entry, accounting, invoicing, and inventory control to be computerized. Current practices indicate a definite trend toward the integration of these individual computing centers within the manufacturing firm.

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[1] Gettleman, K.M. and Albert, M.D. *Fundamentals of NC/CAM modern machine shop.* Cincinnati, Ohio: NC/CAM Guidebook, 1983.

In its initial stages, CAD/CAM was not much more than automated drafting. It has steadily progressed toward its goal of integrating the design and manufacturing functions. Some experts say it will lead to engineering without paper! The successful integration of CAD with CAM enables the system to define both the product and the process. This aspect of operation shortens the design cycle, improves the design by making alternatives easier to consider, and offers a database that all members of the business team can access including design, manufacturing, and marketing. The greatest reductions in time and cost are usually expected in the areas of prototype development and production preparation. These improvements are a direct consequence of comprehensive product analyses and computerized simulations regarding future performance.

Although most CAD systems have keyboards, more useful devices for entering design information have been introduced during the past few years. A few of the more widely used items include light pens, touch sensitive drawing boards known as graphics tablets, and a "mouse" which is moved on a nearby surface to control a pointer on the screen. CAD operators use digitizers to read the contours of any drawing or model into the computer. Since their designs are usually stored on computer disks, operators can recall and revise any designs or plans done on the system. Computer-oriented design engineers can reproduce a single part of an image and move it, zoom in on a small piece, change its size, and rotate the design to view it from different perspectives. Most basic systems create two-dimensional drawings. More advanced systems produce images that appear three-dimensional. The most advanced "solid modelers" generate realistic images that are used to analyze a part's performance. These have gained popularity over the previously used "wire frame model" depictors.

CAD/CAM engineers use CAD to prepare the computerized instructions for manufacturing equipment. Man-machine communication in integrated CAD/CAM systems can be accomplished in several ways. Currently in use are: programming languages with various degrees of abstraction; interactive input via interactive communications; menu of graphic reconstruction techniques such as pattern recognition; and higher-level design and process planning languages for task description and sequence control. Still in the developmental stages are processes for system utilization by means of human language for more convenience and speed. The primary aim of these higher-level design languages where information can be entered by voice rather than hand is the definition of complex objects with minimal input. CAD/CAM has been widely publicized and certainly promises extraordinary shortcuts. Interfaces between CAD terminals and computer-controlled machine tools are being perfected on a regular basis (they still have some limitations)[2].

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[2] *Computerized Manufacturing Automation: Employment, Education, and the Workplace.* U.S. Congress. Office of Technology Assessment. Washington, D.C., 1984. (GPO Stock No. 052-003-00949-8)

FLEXIBLE MANUFACTURING SYSTEMS (FMSs)

One of the most exciting technologies in the manufacturing arena has earned recognition as the "sci-fi factory of the future." This technological strategy is most commonly referred to as a **flexible manufacturing system** (FMS). Such a system may cost up to $50 million to implement into a traditional, labor-intensive organization. A typical FMS is characterized as a computer intensive environment where the functions of manufacturing, material handling, tool management, shop floor scheduling, quality assurance, and workpiece accounting are completely integrated. For instance, a computer directs an automated vehicle or robot to bring a piece of raw material to a particular cell on the factory floor. Next, a computer-directed machining center performs a number of different operations to produce a finished part. This item is then sent out to the shipping dock or on to an assembly line. Within this particular FMS example, the part itself is never touched by human hands.

Several machine builders in Japan, the United States and Europe are working on the development of flexible manufacturing systems. Some of the well known applications in the United States are at General Motors, Caterpillar Tractor, Borg-Warner, Ingersoll-Rand, General Electric, and John Deere & Company. Japanese factories that have received international recognition include Fanuc, Ltd., Hitachi, Toyoda Machine Works, Fuji Electric Shaft Line, and Toyota Motors. Several FMS installations are in operation among European auto makers including Renault, Citroen, Peugeot, and Fiat.

A fully operational FMS, such as the one pictured in Figure 7.7, provides many advantages. In a conventional machine shop, even one that uses NC

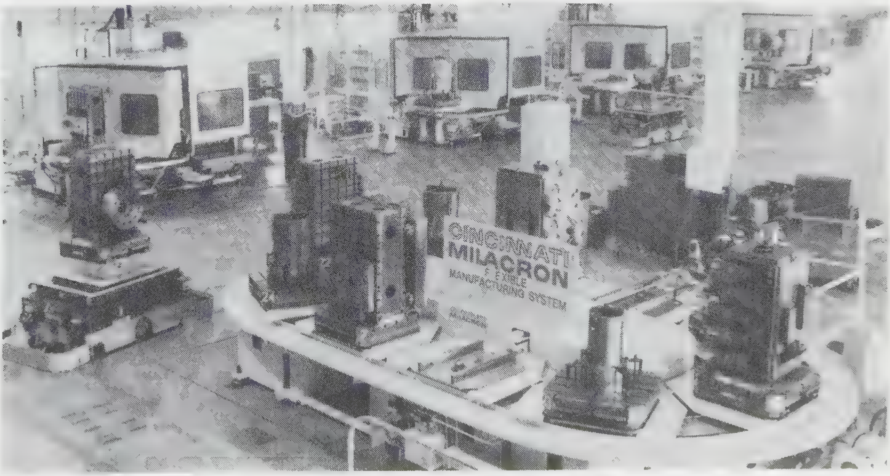

Figure 7.7 A flexible manufacturing work cell in one of Cincinnati Milacron's Ohio plants. Note the efficient arrangement of equipment across the shop floor. Factories of the future will be more compact by design and space requirements for inventory will be significantly reduced. (Cincinnati Milacron)

tools, workpieces are often machined, allowed to wait, then machined again, allowed to wait again, and so forth. By comparison, an FMS makes manufacturing faster since parts are moved quickly and systematically from one work station to the next. This allows the manufacturer to reduce inventories of partially finished parts. This tactic often provides one of the most significant cost savings of an FMS.

An FMS may include not only machine tools but also other work stations such as inspection devices or heat treating machines. Most FMSs have at least 4 work stations and some have as many as 32. Transporting the workpieces from one station to the next may involve conveyors, monorails, carts on tracks, carriers that follow wires on the floor, or other automatic materials handling vehicles (AMHVs). It is the materials-handling system that seems to be the most critical aspect of an FMS. Many of us view the process of moving parts from place to place as an uncomplicated and very mundane job. This perception is somewhat misleading in the sense that materials handling should be thought of as the "glue" that binds a factory together. It may be possible for an FMS to reroute parts around a broken work station but, a breakdown in the automatic materials handling system often spells disaster for the corporation.

Engineering a materials-handling system which takes into account complex logistics while accurately placing parts on work stations is not an easy task. When humans are responsible for materials transport, they are usually capable of making simple adjustments. In other words, they normally do not run into each other! These behavioral responses are more difficult for automated systems to accomplish. Designers have attempted to solve this particular FMS deficiency by including backup paths or by using vehicles guided by wires in the floor conveniently routed around potential obstacles.

The FMS approach may reduce the labor force to between 10 percent and 15 percent of that required to run conventional facilities. Business leaders responsible for the implementation of an FMS sometimes experience emotional difficulties when dealing with the fate of their displaced workers. Additionally, these mangers must effectuate a critical balance among demand, product, machine technology, and capacity usage flexibilities. Managers who lack some sort of technical background may be inclined to shy away from FMSs to avoid these incremental burdens.

Flexible manufacturing systems continue to experience the growing pains of adolescence—both technically and operationally. Among the FMS technologies still being developed or recently introduced one might discover: computerized feeding systems; head changer systems; laser machining; precise automatic measuring gauges; and self-propelled vehicles guided by light beams or radios. Researchers are also attempting to develop automatic methods for generating parts and designing adaptive control mechanisms. These will, ideally, compensate for unavoidable tool wear and tear, and those unexpected human errors. It has been projected that the more mature FMSs of the future will require no work force what-so-ever. Subsequently, the phrase "automated" factory might be replaced with "automatic" factory.

INTRODUCING MAP AND TOP

A "birdseye view" of a technologically progressive manufacturing plant portrays the presence of machine vision systems, robots, automated handling systems, and flexible machining cells. What could possibly be missing from this picture? The one thing that seems to be a problem stems from the fact that many of these programmable devices are unable to communicate with one another. Two innovative solutions to this obstacle were conceptualized during the early 1980s. MAP, for **manufacturing automation protocol** was initiated by General Motors Corporation. TOP, for **technical and office protocol** surfaced at Boeing Company. The ultimate goal of each of these concepts is to provide standardized communications links that meet the requirements for computer-integrated manufacturing (CIM).

MAP and TOP are specifications relating chiefly to communications standards. Without too much difficulty, a local area network (LAN) can be installed inside a company to link its computers to robots and other pieces of programmable equipment. For many years, manufacturers were confronted with more than 250 different types of LANs. None of these had adopted a universally agreed upon inter-vendor operability. Industrial-data communications networks were created as an afterthought. Computer-based manufacturing systems were often deployed in response to individual application requirements and the communications subsystems were addressed after the fact. Computer and programmable controller manufacturers were requested to provide some means to network their computers. In the long run, a number of proprietary networking schemes emerged which led to the current "islands of automation" dilemma. In other words, the IBM computers in machining cell #27 are unable to converse with the DEC computers being used in the CAD center. MAP and TOP have been described by the experts as the missing cantilevers that can bridge these islands and enhance communications.

Without an improvement in shop floor communications, CIM can not become a reality. CIM requires the integration of all plant-floor applications such as CAD/CAM and manufacturing cell control. Immediate access to data for statistical quality control is also essential. MAP and TOP can make the transfer of files and messages among dissimilar computers a high speed affair. This has become a *must* in organizations who are committed to full-scale CIM. For instance, an engineer on the shop floor must be able to gain quick access to the office-based NC programming computer and the corporate mainframe to relay production changes or requirements in order to support "just-in-time" production demands.

While MAP is being marketed to integrate computers on the factory floor, TOP standards promise to lower administrative computer-system costs, provide a wider choice of products, and ensure that disparate equipment is compatible. TOP is promoting a single set of standards for all office computer communications throughout industry. These standards should ultimately allow common communication methods for the exchange of information in a variety of applications such as electronic mail, word processing, graphics, and database management. MAP and TOP both promote multi-vendor systems, mixing and matching products, and the selection of vendors by the merits of their individual products rather than the total systems they offer.

Both approaches to networking are based, to a large extent, on the International Standards Organization's (ISO) open-systems interconnections (OSI) reference model. The OSI model is an internationally accepted set of electronic standards that enable information to be transferred from one computer to another. The seven-layer model is intended to allow computer systems to interact on a "peer-to-peer" basis. Each layer in one system communicates with the same layer of the other system. Refer to Figure 7.8. Vendors in both the industrial and office automation disciplines will eventually adhere to MAP and TOP standards. This will take time, but will provide significant benefits for industrialists who presently advocate computer-integrated manufacturing (CIM).

INTERNATIONAL STANDARDS ORGANIZATION (ISO) OPEN SYSTEMS INTERCONNECTIONS (OSI) SEVEN-LAYER REFERENCE MODEL

THE LAYERS		
7 APPLICATION	Provides all services directly comprehensible to application programs.	**Application**
6 PRESENTATION	Transforms data to and from negotiated standardized formats.	**Interoperation**
5 SESSION	Synchronizes and manages dialogs.	
4 TRANSPORT	Provides transparent, reliable data transfer from end node to end node.	**Transport**
3 NETWORK	Performs message routing for data transfer between nodes.	
2 DATA LINK	Error detection for messages moved between nodes.	
1 PHYSICAL	Electronically encodes and physically transfers messages between nodes.	

Figure 7.8 Chart that depicts the International Standards Organization's seven layer (OSI) model. (Boeing Computer Services)

ROBOTICS: APPLICATIONS AND IMPACTS

For almost two decades, robotics has been making inroads in automobile manufacturing. It is becoming apparent that robots will soon occupy a large place in all types of business enterprises. Robotics is moving into warehousing, shipping, and retailing. Robots are also being used in offices and a few service industries including hotels, hospitals, restaurants, and landscaping. With this in mind, the robotic lawnmower scenario presented in the DATELINE section of this chapter may soon become a reality.

Modern robots come in all shapes and sizes. Very few of them bear any resemblance to the humanlike androids pictured in contemporary science fiction movies. Most of them should simply be viewed as computers to which limbs, organs, tools, and other pieces of equipment have been attached. Although somewhat less intriguing, a more technical term for today's robots is "programmable manipulator." The most commonly used definition for an industrial robot is "a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable motions for the performance of a variety of tasks."[3] The key word in the phrase is reprogrammable. This reprogrammable robotic feature differentiates industrial robots from other forms of so-called "hard" automation which may not allow for easy changes. Research efforts in the fields of artificial intelligence and expert systems may one day extend the capabilities of these mechanical employees. For the present time, industrial robots still have limitations in comparison to human workers.

Regardless of their size and particular function, industrial robots have three main parts. Refer to Figure 7.9. The main body of the robot is called the **manipulator**. Its base is generally fastened to the floor. Some robots can move on tracks and others are hung from overhead supports. The power mechanism which moves the arm of the robot is dependent on size. Hydraulic power is used for heavier arms, electric or pneumatic power on lighter units. The number of joints, or the degrees of freedom of the arm, will determine the robot's dexterity as well as its cost.

The second essential part of the robot is an **end effector**. This is the gripper, welding gun, or other tool to enable it to execute its assigned tasks. Grippers are normally custom-made and they vary a great deal. Some can lift several heavy objects at one time. Others can grasp a fragile component without damaging it.

The **controller** is the program and computer used to guide the robot and direct its movements. One way to program the unit is to guide it through the desired exercise. A human worker moves the arm physically or with switches on a control panel while the controller records the path. This is an effective programming method for tasks such as recording the curved motions needed to produce an even coat of spray paint. On the other hand, the path is difficult

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[3] Robot Institute of America. *Worldwide survey and directory on industrial robots.* Dearborn, Michigan: Author, 1981, p. 1.

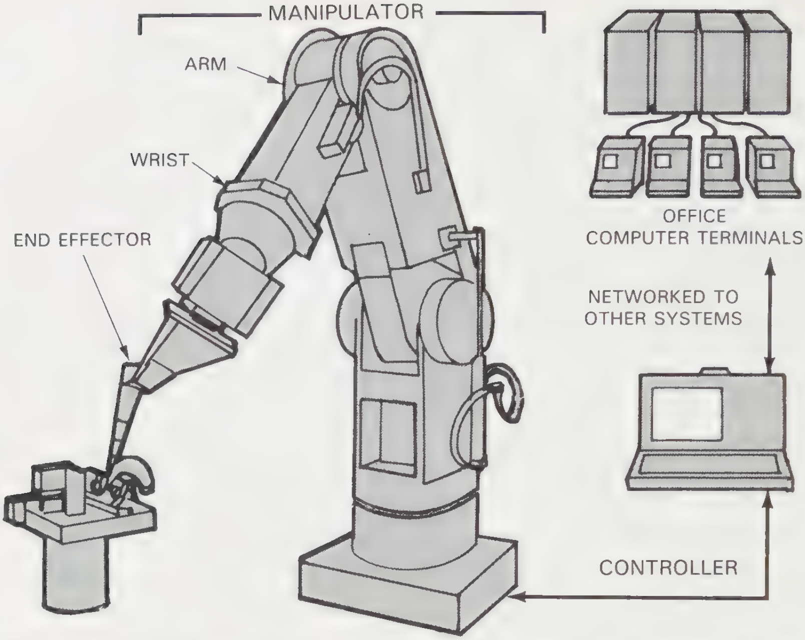

Figure 7.9 Line drawing to show three main parts of an industrial robot.

to edit or revise without completely re-recording or re-performing the task. Off-line programming is when an operator writes a program at a terminal to direct the robot. Off-line programs can be written without interrupting production. They can also give robots different sets of instructions contingent on the situation at hand (if no part is available for treatment, wait for the next cycle.) One of the current developments taking place in off-line robot programming is direct connection with CAD/CAM systems.

Some manufacturers classify industrial robots as to whether they are servo or nonservo. A nonservo robot uses mechanical stops or limit switches to control its movements. This type of robot is less expensive and is normally used for simple maneuvers such as point-to-point transfers. Servo robots make use of software to control the manipulator's motions. Due to their greater flexibility and the controllability of the motion sequence, most modern industrial robots are servo-controlled.

The industrial robot is having a significant impact on the strategies being envisioned by manufacturing managers around the world. One of the forces that seems to be fueling the growth of robot sales is the trend toward flexible automation in a variety of industries. Although published estimates seem to vary widely, the Robotics Industries Association recently reported that the United States robot population had increased by a factor of ten to more than 20,000 in less than a decade. In the early 1980s, close to 90 percent of the industrial robots sold in the U.S. were purchased by automobile companies.

Since other industries such as electronics, aerospace, and light manufacturing are increasing their use of factory automation equipment, the automakers are presently buying only half of the newly built robots in this country. Whether the robots are simple or sophisticated, market analysts are convinced that the robotics industry will continue to grow and expand its horizons.

HIRING ROBOTS TO WORK FOR US

The decision to implement robotics into a plant's manufacturing and production operations should be based on a comprehensive analysis of the entire process. Industrial robots are not a panacea (cure-all) for every manufacturing situation or firm. Not everything can be automated with industrial robots. Robotics implementation is a long-term rather than a short-term decision since most industrial robots are currently designed to operate for more than ten years. Most importantly, it is essential to recognize robots for what they are. Robots are not mechanical people—they are tools within an integrated manufacturing system.

A robot is a sophisticated combination of hydraulics, mechanics, electronics, and computers. The price tag for this technological tool is contingent on its complexity. The *Wall Street Journal* reported that the average cost for a new robot was around $60,000. Simple "pick-and-place" robots with two or three degrees of freedom cost $5,000 to $30,000; more complex systems could cost more than $100,000. Several of the frontrunners in the robot manufacturing industry during the same time period included: GMF Robotics (a joint venture between General Motors and Fanuc, Ltd. of Japan); Cincinnati Milacron; Westinghouse/Unimation; Automatix; IBM; General Electric; DeVilbiss Company; and Prab Robots. These industrial organizations are an excellent source of information regarding cost and important operating features. They are quite useful when managers are contemplating the purchase of industrial robots and/or considering a retrofit application for robots in their plant.

What sorts of tasks can a manufacturing manager expect an industrial robot to be able to master? Many of the first robots were used (and still are) for monotonous or dangerous jobs and for loading and unloading heavy parts. More sophisticated robots are presently becoming practical for jobs like assembling switches for appliances, sanding missile wings, and inspecting parts' dimensions. The following list provides a summary of some of the most common industrial operations assigned to industrial robots.

1. Assembly Operations. While spot-welding is dominant in this area, some arc welding is also done by robots. Ford Motor Company has also experimented with high speed laser welding. Electronics assembly has experienced growth recently. It is looked upon as a major area in the future involving part insertion, circuit wiring, and soldering.
2. Materials Handling. One of the first uses of industrial robots, this application includes point-to-point transfers, machine loading, and handling palletized goods.

3. Spraying. The most frequent incidence of this task is spray painting done by automakers and major appliance manufacturers. Spraying sealants and rustproofing material is another application that is becoming more common. Some furniture makers are employing robots to apply first a stain and then a lacquer finish to their products by mounting two nozzles on the same unit.
4. Inspection. This area may involve gauging and measuring tolerance on manufactured parts. Robots are also being used with ultrasound for leak detection of assemblies such as the door seals on automobiles.
5. Cutting and Deburring. These finishing operations are efficiently and accurately accomplished by robots. They may be equipped with a high-pressure water jet in order to deburr highly intricate castings or to cut excess material (flash) off irregularly shaped components. The use of laser cutting tools is in the experimental stage.

As research and development improve machine vision systems, a whole new array of robotic applications will emerge. See Figure 7.10. Equipped with camera eyes or optical scanners, robots will be able to select, inspect, assemble, and place parts or products on machines, trolleys, and warehouse shelves. The National Bureau of Standards recently forecasted that 90 percent of all industrial inspection will be done by robot vision.

Optically equipped computer-robots in Japan are already being used to both inspect and grade agricultural produce. Martin Marietta is developing an optically equipped robot in Florida that will be able to pick the ripe oranges and leave the unripe ones on the trees! Nabisco Brands is looking forward to using a robotic palletizing system at its Toronto margarine plant. It reportedly will employ optical sensors that permit the robot to decide which pallet to load which boxes onto and then do it. The Japanese are soon expecting to use robots to spread fertilizer in their fields and spray insecticides when necessary. In Australia, robots are being designed to perform the back-breaking work of shearing sheep!

Persons who ponder these and other equally fascinating scenarios of life with robots tend to fall into two very opinionated groups. The first group makes dismal projections regarding huge unemployment levels and long breadlines. Robots are portrayed as the anthropomorphic (human characteristics ascribed to nonhuman things) enemy robbing people of their lives, their livelihoods, and their dignity.

The second group is less pessimistic and somewhat more pragmatic (factual or practical). These individuals feel that although robots can be utilized effectively throughout the manufacturing process, robots cannot be substituted effectively for people in today's factories. One robotics expert noted quite astutely "Using robots this way would merely perpetuate in metal the inefficient ways humans have long tried—without success—to be machines."[4]

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[4] Daniel Whitney. Real robots do need jigs. *Harvard Business Review,* May-June 1986, *64*(3), p. 110.

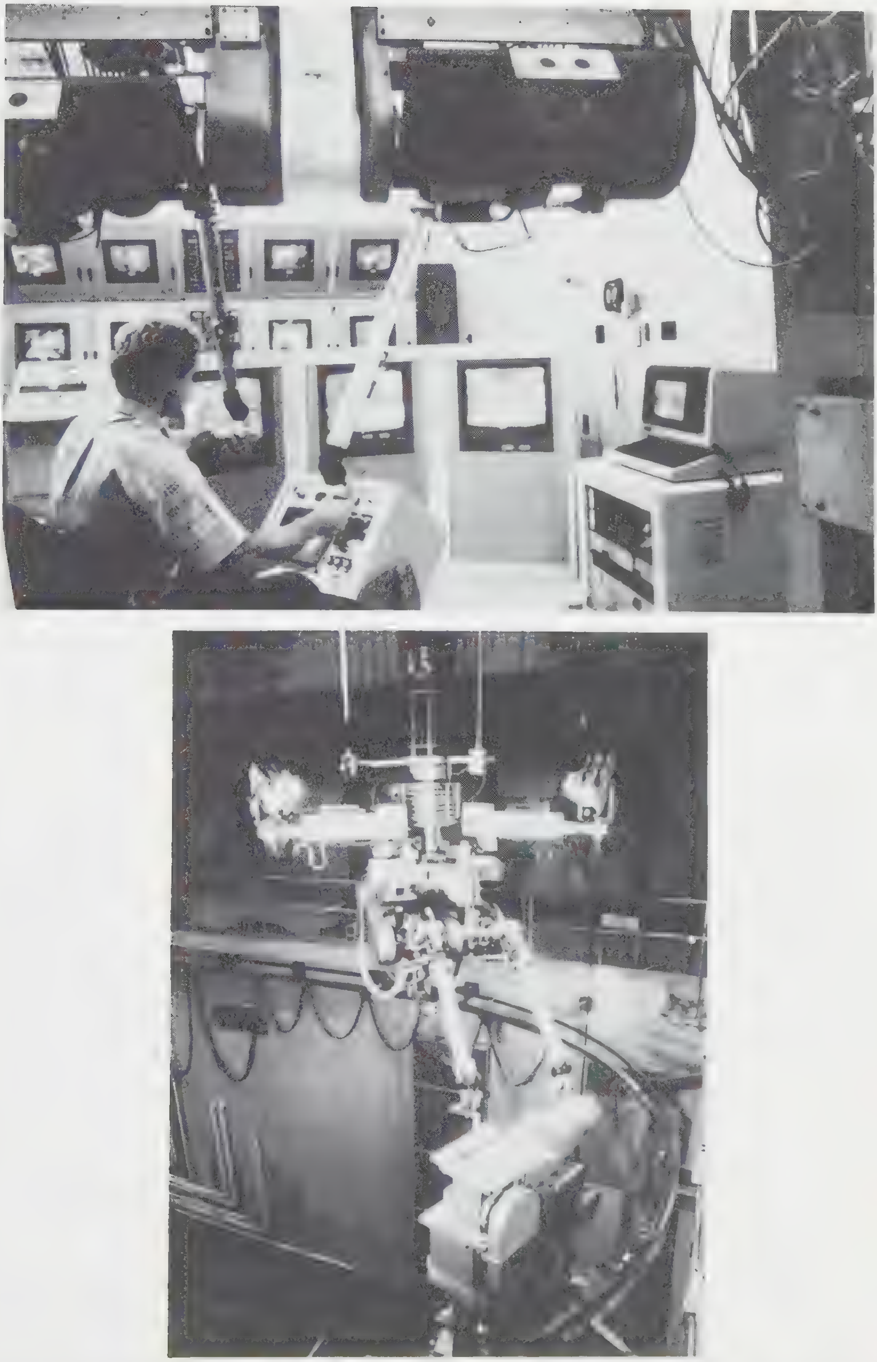

Figure 7.10 The robotic "master" unit (above) is used to manipulate the "slave" robot (bottom) in an adjoining room. This scene illustrates a demonstration of technologies being developed for safe handling of hazardous materials. (Martin-Marietta Corp.)

Robots have certainly arrived on the scene in American industry but without the catastrophic consequences projected by the first group mentioned above. The percentage of the work force employed in manufacturing today is much lower than a decade ago. The role of robotics in the downward shift has not been as dramatic as one might think. Industrial robots have not replaced entire shifts of workers nor are they expected to do so in the near future.

Even still, many employees express concern about job security when confronted with a discussion on robotics. The extent to which robots are successfully implemented is generally a reflection of the amount of cooperation and communication among levels of management, between supervisor and employees, and between management and the engineering staff. Industrial psychologists in the United States suggest that the communication, concern, and sensitivity displayed by management can be the most important factors for success on the shop floor. In a similar vein, one of the fundamental policies of Japanese trade unions in dealing with the introduction of robots is to always secure, in advance, joint consultation with management. The Japanese do not oppose the implementation of robotics technology as long as the conventional management policies of life-time employment and a seniority wage system are maintained. In all industrial nations where robots are being initialized, employees must expect, and should look forward to, changes in the work environment. These changes need not be devastating to the work force. Humanistic decision-making coupled with the acquisition of reliable technical information among today's manufacturing managers support this theory.

REASONS TO INVEST IN INDUSTRIAL ROBOTS

An industrial organization's future success will be dependent upon its ability to build a manufacturing system that focuses on producing a high quality product at a reasonable cost. The manufacturing system profile must be drawn only after all of the tasks' requirements are fully understood. Labor costs continue to rise while robot equipment prices are dropping slowly. In those instances where it is determined a corporation's needs can best be served through the use of industrial robots, the decision to purchase the equipment needs to be made. The following list provides a summary of the most common reasons a firm might consider adopting robotics technology on either a large scale or even on a pilot test basis.

1. Cost Effectiveness. This is by far the most basic reason. Industrial robots can be far less expensive than other solutions for a given manufacturing problem. They typically have payback periods of less than three years with significant returns on the initial investment.
2. Consistency. This reason is related to the fact that properly functioning industrial robots have a high repeatability rate. Robots are checked frequently with reference to the accuracy of the job they are performing and readjusted if necessary. Consistency often leads to cost savings through less rework in assembly-line applications.

3. Reliability. On the average, robots in use in the United States were reported to have a 98 percent uptime. Robots are being engineered to "live" up to 25,000 hours which is equivalent to about 12 man-years of labor for single shift activities. Industrial robots do not need coffee breaks and they rarely telephone in sick. Reliability aligns with consistency to provide major cost savings.
4. Safety. Positive employee reactions are common when robots assume hazardous, hot, heavy, or monotonous tasks. Safety can mean removing the human worker from an environment that may be filled with potentially toxic or hazardous materials. In many instances, robots are commissioned to do tedious, repetitious operations that no person wants to do.
5. Corporate Competition/Survival. Some firms implement robotics to maintain a competitive edge in response to foreign competition. The edge comes from better-quality, lower-cost products to attract consumer confidence. In particular, the automotive, durable goods, and electronics industries are confronting strong competition from Japanese products of high quality with modest price tags. To stay in business and survive the technology battle, these firms have had to modernize their manufacturing processes.

In sum, the primary considerations for robotics implementation should be the product's characteristics plus the manufacturing process required. Not everything can be successfully automated with industrial robots. Some companies may discover that they require a more traditional mix of labor and machine technology to stay in the black. Stated differently, the purchase of one or several industrial robots is not always a cost effective investment.

PRODUCTION FEEDBACK STRATEGIES

A primary goal of manufacturing management known as quality assurance has been mentioned several times throughout this chapter. Along with the implementation of new technologies, the management of productivity and quality has emerged as a major business strategy in numerous organizations. There appear to be several catalysts driving this trend. The first of these is related to an intensive amount of global competition in all industrial sectors. There has been an increasing demand for better quality goods and services at either the existing price or at a significantly lower one.

A second force stems from the fact production costs have gone up considerably over the past several years. To offset this situation, manufacturers are investigating new ways to improve the productivity of labor using a variety of innovative manufacturing technologies.

Third, the level of consumer education has intensified leading to a better awareness of quality. Public acceptance of manufactured goods is based on strict conformance to specifications. Persons commonly expect the products they purchase to be 100 percent defect-free. They quickly lose confidence in a manufacturer when these expectations are not satisfied.

A widely accepted generic definition of quality is "fitness for use." The manufacturer views fitness for use from the perspective of its ability to process and produce finished goods with less rework, less scrap, minimal downtime, and high output. Customers view fitness for use whenever they consider things like product durability, availability of spare parts, identity, and comfort. Two main aspects of quality are the quality of design and the quality of conformance.

QUALITY OF DESIGN involves the quality features that can be obtained through changes in or manipulation of design parameters. Differences (however, not always improvements) in quality may be achieved by changing the size of the item, the materials used to make it, the equipment used to produce it, the tolerances during manufacturing, and so forth. The QUALITY OF CONFORMANCE is a measure of the extent to which the product conforms to the specifications and tolerances required by the design. Many factors influence this measurement encompassing training, employee motivation levels, complexity of the production process, and the quality assurance system being used.

Consumers evaluate a product's fitness for use through a review of certain "quality characteristics." Depending on the item, any number of features may be critically considered. If the buyer expects the product to last for a certain length of time, quality elements such as its warranty, serviceability, reliability, and maintainability are important. Ergonomic features including comfort, size, and ease of use fall into another category. Finally, one should not overlook the sensory-oriented qualities such as the product's color, taste, fragrance, beauty, appearance, etc. If you have ever been involved with the selection and purchase of a new automobile, you should remember these things well. There is nothing quite like the "new car smell!"

Improvements in quality are made by examining the design and conformance aspects and their associated characteristics. This examination may reveal the need to change the design or institute more elaborate inspection and process control procedures. A major portion of the quality methods presently being used throughout the world were developed by the American Society for Quality Control (ASQC).[5] A few of their widely accepted production feedback strategies are known as statistical process control (SPC), quality cost, total quality control, failure analysis, and zero defects.

QUALITY CONTROL FUNCTIONS

There are a large number of quality control functions that must be executed at different levels of the manufacturing process. The corresponding control activities and the types of data collected at each level tend to vary considerably along the way. Future manufacturing facilities will most likely employ systems to supervise an integrated quality control system. Ongoing research and development efforts have produced several of the building blocks needed for a fully integrated quality control system to be implemented. Bus systems (electrical or optical conductors) are being developed to simplify the interconnection of measuring equipment and computers. These interfaces will use standardized communication networks such as MAP and TOP.

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[5] For information of the ASQC's quality certification programs, publications, etc., contact: Executive Director, American Society for Quality Control, 230 W. Wells Street, Milwaukee, Wisconsin, 53203.

Bar coding is the link to computers revolutionizing material handling in the computer-integrated manufacturing (CIM) environment. Bar coding has already produced dramatic gains in productivity and efficiency due to more precise inventory control, production, shipping, and handling management. The familiar bars and spaces are read by computers equipped with special scanning devices at any point during manufacturing or inventory operations. See Figure 7.11.

Researchers are devising methods to integrate quality control procedures further back into the fabrication process in order to gain more flexibility in manufacturing. Computer technology promises to simplify the use of the many well-known statistical formulas to evaluate quality control data.

Quality control planning is a function parallel to process planning. For each workpiece handled, the measurement parameters, tolerances, and test sequences must be determined. It is also necessary to establish sampling plans, process capability studies, and the amount and type of quality data to be accumulated and stored. This planning operation is normally completed by the company's quality control expert with or without the use of a computerized data storage/retrieval system.

As previously described, quality is the sum of all attributes and characteristics of a product or service which contribute to its usefulness or its ability to perform certain functions. Quality control is therefore a regulatory process through which performance is first measured and then compared with pre-set standards. If necessary, corrective action is taken. A firm's competitive edge is often ancillary (subordinate) to its quality standards. The backbone of an organization's quality control system are the internal, national, and international standards it aspires to guarantee. These standards are essentially a contractual agreement between the manufacturer and the customer. Adherence to publicly accepted standards is the aim of a quality assurance system. When a product defect is discovered, the following questions are of direct interest to the quality control personnel:

☐ Type of defect.
☐ Place of occurrence.
☐ Cause of defect.
☐ Number of defects.
☐ Seriousness of defect.
☐ Cost of defect.

The bottom line is cost, which determines how much time and effort should go into a quality test. A dedicated effort must be made to locate all defects while the product is being fabricated, manufactured, and assembled. Product repair in the field is much more expensive than it is inside the factory.

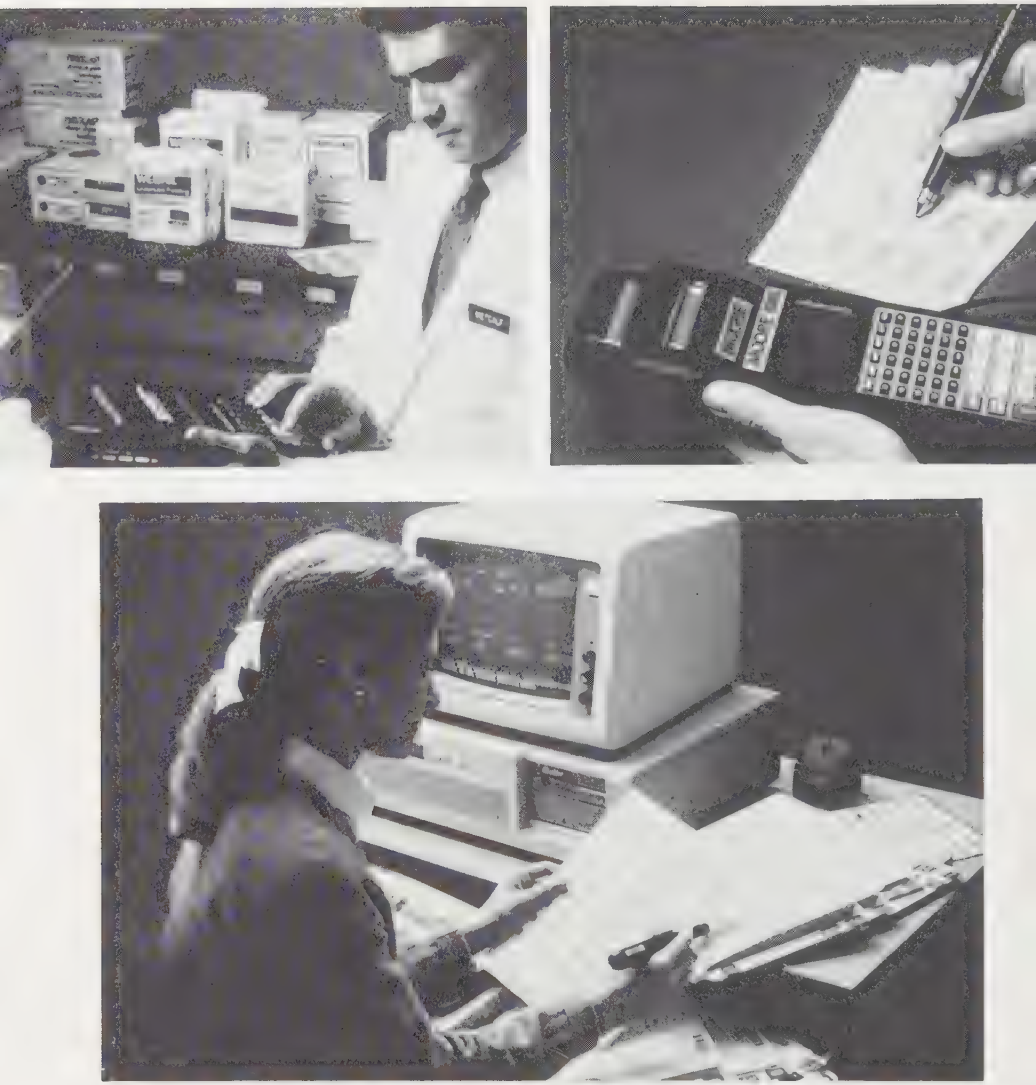

Figure 7.11 These photographs, taken at Moore, Inc., represent barcode application for use in automated on-site systems. The first picture depicts an individual in a hospital Central Supply Room counting inventory assigned to an exchange cart for the purposes of inventory par level replenishment. The second picture depicts scanning the labels corresponding to the products taken from the cart and administered to a patient. This scanning process facilitates two processes: (1) captures the charges, sending that information to Data Processing for patient billing, and (2) makes a comparison between the ''charged goods'' (labels on patient card) and the ''used goods'' (inventory count) to create a discrepancy report tracking the ''lost'' charges. The third picture shows the ability of bar codes to accomplish a tracking system. The bar code tracking scenario can apply to any type of document (job tickets, customer accounting folders, etc.) or the tracking of company assets. (Moore, Business Forms and Systems Division)

An efficient quality control system may be described as a complex adaptive control loop. All critical properties and product performance standards are identified and checked throughout the factory:

1. At receiving.
2. At the location where the parts originate in the manufacturing process.
3. At subassembly stations.
4. During the final acceptance test of the finished product.

Within the system, when the cause of a defect and its place of occurrence are known, measures for its correction or elimination are initiated. Requisite corrective actions may take place at the factory floor level or may extend back into product design. An important aspect of quality control is reaction time. This is the length of time (seconds, minutes, hours, days, etc.) between the instant the defect is recognized and the instant it is corrected. Coordinated efforts between plant managers and shop personnel combined with advanced computerization will eventually lead to shorter reaction times and more efficient quality assurance programs.

PROCESS CONTROL

While quality assurance has traditionally been accomplished through product control or inspection, the focus of process control is on individual operations and the roles they perform in manufacturing. Process control strategies are prevention-oriented as opposed to inspection-driven. The goal of process control is to have each operation functioning within its normal capability limits. This type of control is often referred to as **statistical process control** (SPC).

Process control involves both statistical analysis and increased personnel responsibility for making sure that equipment and processes are operating within acceptable limits. It provides a unifying and validating factor for the overall quality program. It provides management with critical feedback regarding the condition of the plant's manufacturing equipment and machinery. In other words, process control may pave the path toward excellence in timely machine tool replacement. Managers who are committed to their quality assurance program are beginning to realize the "run-it-til-it-drops" strategy for machine replacement is not the way to stay ahead in the international manufacturing race.

The decision to implement process control should focus initially on the identification of two or three critical parameters in each process that must be controlled in order for the process to adequately fulfill its function. Next, the operating ranges of these critical parameters must be specified. After this step is taken, it is possible to go back and evaluate how each process can be improved to tighten the acceptable operating ranges and enhance overall product consistency. Information generated at this stage of implementation should be further analyzed within the facilities enhancement segment (machine replacement, renovation, repair, purchasing) of the quality assurance program. Managers can systematically utilize this input to plan and rationalize future capital improvements.

Process control is fundamentally different from the inspection systems commonly used. The basic philosophy that seems to permeate inspection is: you make it, then you check it to see how good it is. In many cases, if you make enough of it, you ship it out the door unless it is totally disastrous. This type of attitude and approach to manufacturing lies at the heart of the problems many firms have had trying to maintain quality. As an alternative, the basic premise of process control is that the manufacturer knows enough about the operation to keep the system up and running and how to keep it within certain limits. The process control system demands quality by design. If the consecutive manufacturing operations are unable to stay within tolerances, they should not be allowed to keep running.

MATERIAL HANDLING PROCEDURES

Material handling refers to the manual, mechanical or automatic treatment of material when the intended purpose is to move, hold, or control objects either individually or collectively. Material handling may entail controlling material quantities, location, timing, sequence, orientation, alignment, and/or condition. It has been estimated that more than 90 percent of a product's time spent in the manufacturing cycle is consumed by material handling and associated activities. For this reason alone, the effects of material handling on product quality demand serious attention.

The central negative effect of material handling on product quality is damage to the point where it is no longer fit for use. Inappropriate material handling methods may lead to product quality degradation as a result of: positioning errors in fixtures or jigs; weather; dust; static electricity; contaminating vapors; obsolescence; etc. The selection of suitable material handling procedures requires the thorough analysis of materials and process requirements. Ideally, material handling systems should be viewed as an integral part of the manufacturing process as well as the facilities design. Specifically, quality assurance specialists must take into account the number of times each product is handled, the distances over which moves occur, and the length of time the product spends being handled. Analysis and control of these three main variables should result in reduced incidences of product quality degradation.

Some of the most common material-quality-related characteristics a manufacturing firm must deal with are: fragility; surface finish; sensitivity to electrostatic discharge; sensitivity to magnetic fields; environmental sensitivities; and shelf life. From a material handling perspective, fragility may translate into impact, vibration, temperature changes, friction and weight-support tolerances. Furthermore, a product's sensitivities to weather exposure, moisture, temperature conditions, ambient pressures, dust and/or contaminating vapors demand specific tolerances. These tolerances subsequently lead to decisions regarding appropriate material handling methods, movement paths, and storage locations.

One of the most direct strategies that can be used to enhance product quality throughout the manufacturing process is to minimize the number of times materials must be handled and shorten distances of travel between workstations. Several of the computer-integrated manufacturing (CIM) strategies described earlier respond directly to this recommendation.

SUMMARY

The American manufacturing portrait seems somewhat less gloomy today than it did just a few years ago. Manufacturing managers in all types of firms are taking a critical look at a variety of new and innovative production operations. Most of these fall under the CIM (computer-integrated manufacturing) umbrella where a sophisticated blend of computers, machining centers, industrial robots, and human labor is fundamental. The fully automated process of mass and continuous or flow production, dominated by computer-aided control, may become a reality with the next decade.

In the United States, the first application of a computer-aided system for production operations was developed by General Motors in the early 1960s. Theirs was not directly related to manufacturing but to product design. The wide array of CIM technologies has begun to break down the traditional institutional barriers between design and other departments. Full scale integration among design, manufacturing, and marketing will be much more common in tomorrow's factories.

Breakthroughs in automation technology are being made as you finish this reading. More sophisticated industrial robots are not only becoming available, but their price tags are dropping a little more each year. Continued advancements in computer-assisted process planning (CAPP) will reveal much more precise methods to maintain an effective quality assurance program. In order to keep their companies on the leading edge, manufacturing managers must keep abreast of the technological changes to increase their productivity and enhance the quality of their products. While these business objectives have been around for years and have earned a reputation for being "timeless," the technologies available to attain them seem to be much more ephemeral (lasting a short time).

DISCUSSION QUESTIONS

1. In the eyes of some technologists, CIM is not a specific technology. Develop a statement that either defends or refutes this point of view.
2. Explain some of the benefits manufacturing firms have realized as a result of adopting group technology principles. Use a specific industry to exemplify your explanation.
3. How does the JIT philosophy differ from traditional manufacturing principles in the United States? What potential problems might be associated with its adoption in, for example, a garment manufacturing plant in Freeport, Maine?
4. Briefly describe what is meant by the "islands of automation" dilemma inside a manufacturing enterprise.

5. Provide a description of a "personal robot" that sets it apart from an "industrial robot." What uses might you project for personal robots in the near future? When might a manufacturing firm's business plan be inclined to avoid using an industrial robot on the shop floor?
6. How might a quality control engineer distinguish the term "quality assurance" from "quality control?" Your explanation should include some reference to the "process" and "inspection" concepts studied in this discipline.

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Chapter 8

UNITED STATES TECHNOLOGY TRANSFER

DATELINE

Kotzebue, Alaska

Stripped of their ancient lifestyle by modern technology and disoriented by the invasion of 20th century culture, Alaskan natives are experiencing an alarming dose of culture shock. They are succumbing to alcoholism, drug abuse and suicide as desperate strategies to cope with technological change.

Until recently, a man needed 30 days to go out on his dog sled and hunt enough caribou to feed his family. With the advent and widespread introduction of snowmobiles, he can hunt the same amount in two days. Does he cease to be hunter during the other 28 days . . . .

INTRODUCTION

The international technology transfer network is a topic that has received much critical analysis since the end of World War II. At that time, the United States began to export a greater number of manufactured goods to war-torn European nations. On the home front, the United States government continued to increase its domestic expenditures on military programs and aerospace research and development projects.

A loose interpretation of the term **technology transfer** as related to the above events refers to the development of a technology in one setting which is then transferred for use in another setting. Stated differently, technology transfer is the process by which technology developed for one purpose is employed either in a different application or by a new user. Specifically, the transfer of United States technology helped to speed up Europe's recovery process. By the mid-1950s, increased European competition emerged in the U.S. export markets. Similarly, significant technological developments occurred in the United States commercial sector as a result of sizeable government R & D spending. This served to reduce the technical and market risks that would have otherwise been confronted by individual industries. As a result, the 1950s witnessed the introduction of numerically controlled machine tools, integrated circuits, commercial jet aircraft, and communications satellites.

A more comprehensive explanation of the technology transfer concept evolves throughout a complex and somewhat controversial network of activities. This TRANSFER CONTINUUM is marked at one end by the uncritical transfer of technology to reluctant recipients. The opposing end of the same continuum is replete with covert activities akin to high technology espionage. This chapter discusses a variety of topics and events relevant to the contemporary United States technology transfer dilemma.

1. What are the key patterns, motives, and channels associated with technology transfer activities?
2. Should the United States continue to address the "technology gap" that exists between the creators of technology and the borrowers of technology?
3. What strategies and guidelines can be employed to determine the extent a specific technology can and/or should be transferred to another nation?
4. How rapidly do industrial innovations spread from one country to another? Which factors determine the relative ease the recipients can begin producing these innovations on their own?

KEY CONCEPTS

As you study this chapter, there are several key concepts and terms you should become familiar with:

Appropriate Technology
Demand Lag
Foreign Direct Investments
Globalization
Imitation Lag
Licensing
Reverse Engineering
Risk Assessment
Risk Taking vs. Risk Shifting
Technology "Mix"
Transfer Channels
Turnkey Plants

THE INTERNATIONAL TECHNOLOGY TRANSFER PROFILE

It is evident the technology transfer process encompasses a diverse complement of activities. There are, however, a few key elements used to examine a majority of the activities in a comparative manner.

The first key element involves the transfer item itself. What is being transferred (product, process, information, etc.)? Secondly, who is the technology donor (who possesses ownership rights to the transfer item)?

Thirdly, who is the technology recipient (an individual, manufacturing firm, or the residents of an entire geographic region)? Of central concern is the recipient's capability to effectively adopt and/or implement the technology once it has been transferred. In some cases, lesser developed nations have particularly poor capacities to assimilate new technology.

A fourth element for comparison is the channel used to accomplish the transfer. How will the transfer item be delivered from the technology donor to the recipient? Typical transfer channels include: foreign direct investment, licensing, and the direct purchase of manufactured goods.

Finally, the technology transfer process may be studied through an analysis of the rate of diffusion of the technology. The concepts of imitation lag and demand lag provide two perspectives for this examination.

TRANSFER CHANNELS

The flow of technological innovations and information through the contemporary international network is a continuous process that occurs through any number of avenues. See Figure 8.1. The mode of transfer is influenced directly by: the nature of the technology being transferred; the commercial considerations as well as the economic incentives associated with the transaction; and the expectations expressed by the recipients of the technology.

Commercial transactions between American and foreign firms seem to form the foundation for the international flow of technology. The underlying motive in a majority of these cases is not technology transfer. These interchanges are usually associated with the potential for a significant return on investment or the desire to gain market access for future investment opportunities. A "human interest" dimension regarding the degree to which the recipients will benefit from the new technology may never even be considered.

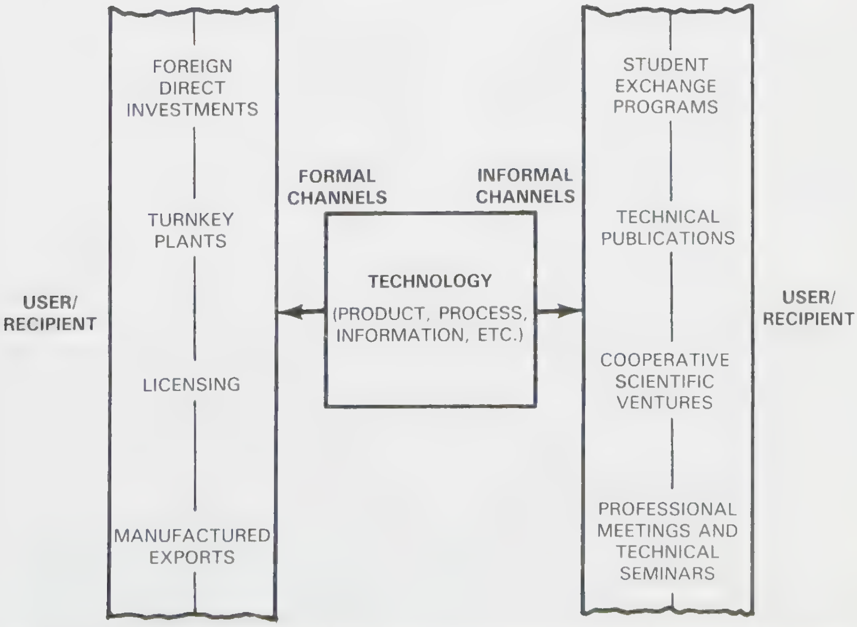
USER/
RECIPIENT
FOREIGN DIRECT INVESTMENTS
TURNKEY PLANTS
LICENSING
MANUFACTURED EXPORTS
FORMAL CHANNELS
INFORMAL CHANNELS
TECHNOLOGY
(PRODUCT, PROCESS, INFORMATION, ETC.)
STUDENT EXCHANGE PROGRAMS
TECHNICAL PUBLICATIONS
COOPERATIVE SCIENTIFIC VENTURES
PROFESSIONAL MEETINGS AND TECHNICAL SEMINARS
USER/
RECIPIENT

Figure 8.1 Typical channels for international technology transfer activities.

The principal channels through which technology is FORMALLY TRANSFERRED from one country to another include foreign direct investments, turnkey plants, licensing and manufactured exports. Numerous INFORMAL TRANSFERS occur via student exchange programs, professional meetings, technical seminars, cooperative scientific ventures, and the dissemination of technical and scientific publications. This list is certainly not exhaustive, but an examination of these types of transnational channels will enhance your understanding of the complexity of the exchange procedures related to technological products and knowledge.

FORMAL CHANNELS

Foreign direct investments represent a key channel for the transfer of technology. These are generally made with commercial considerations in mind. A manufacturing firm's decision to establish overseas subsidiaries is often related to its desire to reduce current distribution costs, to avoid hefty import duties, or to manufacture with lower labor cost. Nevertheless, the firm's transition from a national to a multinational corporation provides an environment highly conducive to technology transfer.

In this type of endeavor the technology donor is the parent firm who claims either full or partial ownership of the foreign subsidiary. It is typical for the recipient country to provide material and labor resources while the parent firm assumes responsibility for the capital, technology, management and marketing skills.

It seems natural to assume the economic incentive alone should provide motivation for the parent firm to do everything possible to insure the transfer proceeds efficiently. If they are successful and if an effective working relationship develops between donor and recipient, technology transfer occurs in a variety of ways. Most commonly, the technology donors train the resident operatives and managers, communicate with engineers and technicians in order to translate critical information and may ultimately encourage the local suppliers to upgrade their existing technology.

In a growing number of instances, the recipient nations in these transactions are expressing a desire for greater control over the local enterprises of multinational corporations. This has produced a trend toward joint ventures wherein the subsidiary is partially owned by the parent firm and partially owned by public or private interests within the host country. Both parties contribute capital to the project, and the management, control, and profits are shared in proportion to each party's equity in the enterprise.

Turnkey plants provide another example of a channel for technology transfer. In this type of operation, the technology donor constructs a fully operational production plant for the recipient nation. The term "turnkey" refers to the notion that once the facility is completed the recipient need simply "turn a key" to initiate the production process. Since the parent firm retains no equity interest in the plant after its completion, turnkey operations are more accurately described as a contractual sale between the party with the technical and managerial expertise and the party that has requested this technological assistance.

Varying levels of technical knowledge and skill are transferred via this form of exchange. In some cases, the receiver can contract to have the donor thoroughly train its local technicians and managers to be able to operate the facility on their own. In these instances, the technology donor leaves the site upon the completion of the construction and/or training project.

If, on the other hand, the recipient feels it lacks the capacity to execute the skills needed to effectively operate the new technology, the seller may be asked to stay on and provide assistance even after the plant is finished. This type of request will generally require a formal management contract and/or technical service agreement. This type of contractual agreement combined with the turnkey operation itself, becomes an extremely effective mechanism for technology transfer. Specifically, a high level of personal interaction between the two countries over an extended period of time is necessary. A considerable amount of on-site technical information and experience eventually becomes a mutual acquisition.

Licensing is one of the primary mechanisms unaffiliated firms employ for transferring technology among themselves. The license is an agreement that specifies the conditions under which the recipient party may employ the donor's technology. In other words, the license agreement is technology-specific and it may cover a patented process, trade secret, manufacturing right, trademark, or the sales and distribution rights for a particular product. The exact terms of the agreement are arrived at through bargaining between the owner of the technology and the purchaser. In most cases, the licensor receives either a lump sum payment at the time of transfer or later receives a predetermined percentage of resultant sales in the form of royalty payments—sometimes both.

Licensing agreements often specify restrictions on the use of the technology item being transferred in order to protect the donor's competitive position as well as its current markets. For example, the licensee may be prohibited from re-exporting the resulting products and/or services it develops through the use of the newly acquired technology.

Licensing is most useful as a technology transfer mechanism in situations where the recipient nation has a high capacity to absorb the technology being transferred. Licensing another entity's technology can be quite beneficial for several reasons: it provides access to current technologies at minimum cost; it reduces the duplication of effort and can save a significant amount on the costs of in-house research and development efforts; and, it may help to raise the recipient's level of technical competence if supported with an orientation training program.

Export of manufactured goods represents another principal channel for international technology transfer. In terms of dollar volume, the sale of technology-intensive products represents the dominant mode of technology transfer today. The mere existence of a new "gadget" in the recipient nation may result in the transfer of technology in the form of increased knowledge, skill, or convenience.

In many instances, the core technological data and know-how is normally difficult (if not impossible) to extract from the products that have been imported. Subsequently, this channel for transfer may not be perceived as the most efficient choice. On the other hand, numerous recipient nations have demonstrated very astute "reverse engineering" capabilities in the past several years. This introduces a unique twist into the transfer network wherein the imported technological device is carefully disassembled, examined, and eventually copied by the purchasing agent.

INFORMAL CHANNELS

Noncommercial avenues also make a significant contribution to the international flow of technology. For example, governmental agreements between the United States and other countries are set up on a regular basis to exchange technical information or to conduct cooperative research and development projects. These types of endeavors usually involve extensive contact between government representatives, tours of industrial plants, and the establishment of domestic training and educational programs. The information exchange is purported to be mutually beneficial to all participants involved. A few contemporary areas of concern that have initiated or stimulated these types of agreements include environmental protection, global energy resource management and national defense strategies.

Scientific and technical publications provide another outlet for the transfer and exchange of information. One of the principal norms of science is to report and disseminate its research findings. Subsequently, journal literature becomes a repository of most scientific knowledge. Technological knowledge may be more difficult to acquire through this channel since it is often proprietary in nature. The review of scientific and technical journals has a serious drawback as a means of transferring technology. The information may well be obsolete by the time it is finally published!

Technical seminars, conferences and trade shows help to compensate for the delays inherent to the publishing circuit. See Figure 8.2. International meetings provide a convenient forum for the development of new contacts and often stimulate a dynamic interchange of opinions regarding contemporary technological projects still "on the drawing board." Manufacturers who invest huge sums in acquiring a prime location on the trade show floor will usually exhibit their most sophisticated and up-to-date technological wares. Valuable technical information can usually be attained through an informal conversation with one of the booth's representatives.

Technology transfer continues to occur through many different types of channels. Those that have been discussed here represent a few of the principal exchange systems utilized in the current international network. Each of these transfer modes has distinct advantages and disadvantages for both the

HEIDELBERG USA

Figure 8.2 A view of the trade show floor at GRAPH EXPO, one of the printing industry's leading national and international exhibitions held in the United States. Participants are given a valuable opportunity to interact with exhibitors to learn about the newest technological breakthroughs in their discipline. (Graphic Arts Show Company, Inc.)

technology donor and the technology recipient. The next section will examine several of these concerns as they relate to the United States' role in technology transfer as an operative device to close the technology gap.

CLOSING THE TECHNOLOGY GAP

The subheading for this section should strike you as being rather presumptuous—it suggests there is indeed a social phenomenon labeled a "technology gap" and, furthermore, the United States is somehow capable of "closing" it. It forces one to visualize a global scenario wherein the United States is leading the world in technological pursuits while the rest of the world's countries are sluggishly lagging behind. This "gap" concept portrays a world order that can easily be assembled into suitable categories such as the "techno-leaders" and the "techno-followers."

Based on your intuitive understanding of "technology" and the "technology transfer" concept it is appropriate to develop an interpretation for this elusive "technology gap" idea. Very few persons dispute there is a general, across-the-board technological difference between the United States and the developing nation of Ethiopia. However, the gap between the United States and the United Kingdom or other so-called "advanced" countries is not so clear cut.

In fact, it is becoming increasingly apparent that international technological leadership constantly fluctuates. Present technology leads may be quickly lost or ceded. A study conducted by the U.S. Department of Commerce revealed the United States share of high technology exports has been trending downward since 1965.[1] Similar findings were reported by the National Science Foundation. Refer to Figure 8.3. The positions of Germany, France, and the United Kingdom have changed relatively little while the Japanese share has expanded sharply, nearly doubling between 1970 and 1985. The United States share decreased significantly from 1970 to 1980, but regained some of its loss in the early 1980s.

An examination of the United States' sectoral performance over the 1965-1982 period shows its export share declined in all but three of the ten broadly defined high technology product groups. See Figure 8.4. The United States' share of communications equipment and electronic components trended

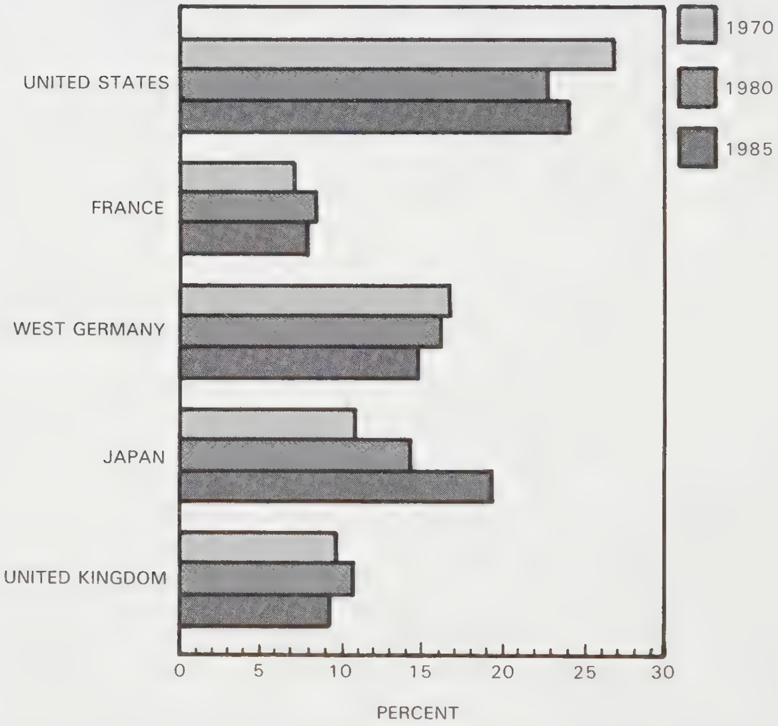

Figure 8.3 "World export shares of technology intensive products" (National Science Foundation. *International Science and Technology Data Update 1987.*)

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[1] Office of Trade and Investment Analysis, U.S. Department of Commerce, *U.S. High Technology Trade and Competitiveness,* (Government Printing Office, Washington, D.C., 1985).

downward through most of the period while Japan became the dominant industrial country supplier of these items. In the mid 1980s however, the United States had the largest share of world exports in most technology intensive product fields. See Figure 8.5. Japan dominated world exports in communication equipment, radio and television receiving equipment, and professional scientific instruments. West Germany nearly matched the United States share of exports in medical supplies and professional or scientific instruments. Even still, statistically, it appears other nations are lagging behind the United States in several areas which brings us back to the technology gap concept.

Up until this point in the chapter, the topic of international technology transfer has been discussed from the perspective of a willing technology donor and an anxious technology recipient. By virtue of its leadership position in the realm of technology-intensive products, the United States is either revered or coveted for its capacity to reduce this technology gap. Does the United States truly have the technical prowess to share its science and technology with those nations who indicate a need or desire for it and subsequently create a new world order?

CREATING A NEW WORLD ORDER

Sociologists, anthropologists, and government leaders have addressed the issue of international development for several decades. One interpretation of international development suggests an impetus (driving force) to improve the standard of living and quality of life for people in countries where food supply,

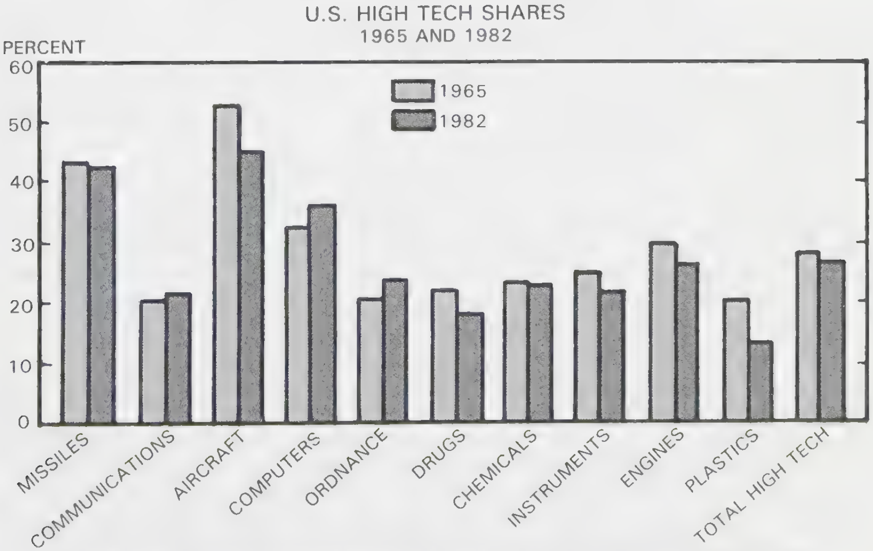

Figure 8.4 United States export share in high technology products. (Office of Trade and Investment Analysis, U.S. Dept. of Commerce)

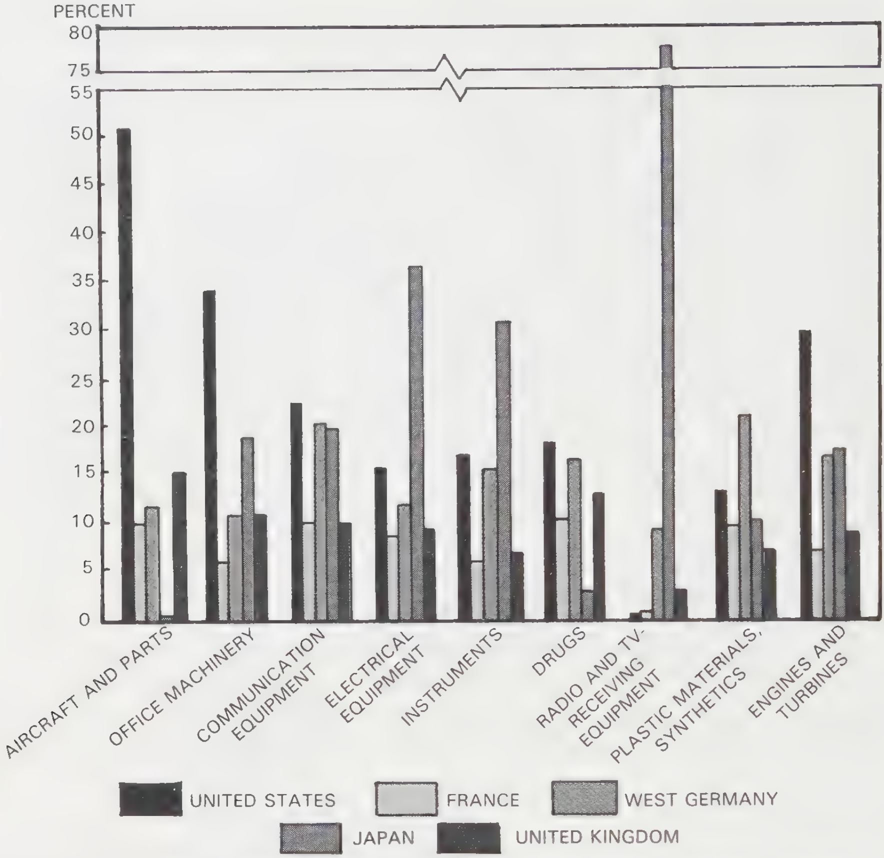

Figure 8.5 "World export shares of selected technology-intensive products" (National Science Foundation. *International Science and Technology Data Update 1987.*)

nutrition, shelter and education are inadequate, and where human beings are unable to live up to their full potential. The gross national product per person is the most commonly referenced statistic used to measure development, but it does not always include these other quality of life factors in its deductions. International development refers then to a combination of improving the quality of life, meeting basic needs, and increasing per capita gross national product.

With these parameters or boundaries in mind, what role can the transfer of technological products and knowledge play in the overall international development scheme? Should a primary objective for United States technology transfer activities be to equalize the levels of technological development on a global scale? Stated differently, should a humanitarian connotation be ascribed to or attributed to a schedule of transfer activities that seem to be heavily commercial as well as competitive in nature?

A brief review of the United States government policies since the Truman administration (1945-53) indicates a general interest in international development has been maintained. However, the motivations have been mixed, and the framework for involvement has changed over the years. A thread of humanitarian concern has endured. The element of competition with the Russians for international influence has continued for several decades. The importance of Third World resources to the United States and the awareness of the potential for export markets in those countries emerged as the quest for technological leadership continued under the guise of development.

Meeting basic needs and human rights became a prominent component of United States foreign policy in the Third World during the late 1970s. More recently, the principal policy objectives of the United States seem to focus on combating terrorism, strengthening the private sector, and supporting United States national security interests. Regardless of the administrative tenets espoused over the years, technology transfer has retained a consuming presence throughout.

Economists have consistently highlighted the importance of technology in stimulating a nation's economic growth. Sometimes the creators of the technology benefit. In other cases, the borrowers of technology benefit. In any event, since technology has speeded economic growth and development in "industrialized" nations, should it not be expected to assist in the development of "less industrialized" countries?

TRANSFERABILITY AND APPROPRIATENESS

Two important aspects of technology transfer to be studied are the nature of the transfer item itself, and the recipient's capacity to adopt the technology once it has been transferred. An attempt to study how certain transfer items are assimilated and modified to suit local circumstances raises the issues of transferability and appropriateness. Should, for example, microwave ovens or microcomputers be transferred to India, the Soviet Union, China, or to countless African nations? Are these technology-intensive items useful to the citizens of these countries?

APPROPRIATE TECHNOLOGY emerged as a discipline whose objective was to develop a form of technology which meets local needs, uses local resources, involves the local residents in the decision-making process, and does not adversely affect the environment. Appropriate technology can also be defined as a technology that "fits" the situation for which it is intended without causing more problems than it solves. The term was popularized by E.F. Schumacher. The term should not be used to describe second-hand or second-rate technology that has become obsolete.

It seems reasonable to assume that no one is in favor of "inappropriate technology." It is also evident that some capital/technology-intensive products have proved unworkable (inappropriate) in certain geographic areas where the level of technological sophistication was not conducive to their implementation.

In other words, the introduction of the new technology directly caused more problems thatn it solved.

Consider the situation in Alaska as described earlier in the DATELINE segment of this chapter. The introduction of modern technology in the form of snowmobiles and televisions has drastically disrupted the serenity of a native North American culture. Most of the Alaskan communities were tied to subsistence activities as the traditional means of survival up through the 1960s. The native residents needed little money to survive and cash flow was based on the sale of products acquired through their hunting and fishing activities. Life was difficult and technically unsophisticated by comparison to the rampant pace of change taking place in most other areas of the United States. However, these people were constantly busy and dependent upon one another for survival in the harsh Arctic climate.

Spurred by the rush to develop an energy reserve in Alaska during the 1970s, high technology uprooted this traditional lifestyle. Today, grocery stores have supplanted subsistence hunting. Most homes not only have electricity but cable television as well. Without the emphasis on hunting and fishing that once existed in these communities, boredom, idleness, and low self-esteem have become the operative terms used to describe the present situation in many Alaskan communities.

Another case of technology transfer's role in international development involved an agricultural project that procured its initial funding from the Rockefeller Foundation. United States scientists went to work with local scientists in Mexico and the Philippines to develop new varieties of wheat and rice that could outproduce existing local strains. What became known as the "green revolution" was considered to be a great success toward the abatement of famine and starvation.

Conversely, this transfer of agricultural technology has hurt the small farmers who could not afford the fertilizer and water required by the new varieties. There is also an increased risk of crop failure through monoculture diseases introduced via the transfer activities. While it is true recipient nations have been able to increase crop yields, the problems of starvation still exist.

These illustrations or examples are not meant to be representative of all technology transfer activities that occur between the United States (as the technology donor) and lesser developed societies (as the technology recipients). There have been and are currently many successful projects being executed through various international organizations. A few of these include the following groups:

1. Intergovernmental Committee on Science and Technology for Development. Created by the United Nations Conference on Science and Technology for Development; its mission is to coordinate and promote UN activities influencing science, technology, and development.
2. United Nations Conference on Trade and Development (UNCTAD). Its mission is broadly economic. It fosters the development of lesser developed countries through trade policy and technology transfer. It has made

numerous demands regarding the international patent system which have stimulated dialogue between industrialized nations and developing countries.

3. Organization for Economic Cooperation and Development (OECD). Headquartered in Paris, it has a membership of twenty-three industrialized western countries and includes Japan. It regularly sponsors studies and conferences designed to help member countries in their scientific/technological decision-making.

Ostensibly, the technology transfer recommendations and projections these organizations provide for those parties seeking assistance are based on the importance of the transferability and appropriateness ingredients with reference to the recipient nation's existing "technological mix."

RATES OF DIFFUSION

Once a technological process or product is introduced to the public, the potential for its introduction into the international technology transfer network is inevitably addressed. From the economist's perspective, the diffusion rate of this new technology quickly becomes a prime dimension for statistical analysis. The rate of diffusion of technology is typically examined from two vantage points. First, after the lead nation begins producing a new device, how long does it take for other countries to obtain the production capabilities to produce the same product? This is called the IMITATION LAG.

Second, after the technology is first introduced into the innovating country's domestic market, how long does it take for it to gain acceptance in foreign markets? This is referred to as the DEMAND LAG or SOCIAL READINESS for the technology.

The imitation lag concept is most closely associated with an earlier discussion which focused on the decline in the United States' share of the export market involving technology-intensive products. Some groups believe this apparent narrowing of the American technological lead is due in large part to the transfer of technology between U.S.-based multinational firms and their overseas subsidiaries. There is the logical assumption these transfers will increase the likelihood key technological information and know-how will fall into the hands of non-U.S. firms who will use it to their competitive advantage.

Besides the initial introduction of a new technology by the developing agent, there are also other factors that seem to influence the speed with which other countries are able to develop and produce a similar product on their own. The first of these factors involves domestic government expenditures on technology-based research and development activities. Organizations that spend relatively large amounts on R & D projects are generally closer to the leading edge of the technological frontier and are more capable of efficient imitation activities.

Several foreign nations have begun to promote R & D in order to strengthen their internal technological infrastructures. A review of the ratio of R & D expenditures as a percentage of gross national product in these industrialized countries appears to confirm a stronger research commitment among these governments when compared with the United States. The United States lead has narrowed considerably due to a precipitous decline in its R & D/GNP ratio through the 1970s. Figure 8.6 illustrates the national R & D/GNP trends in several leading Western industralized nations.[2] West Germany and Japan show decidedly strong upward trends through the late 1970s. France experienced a decline in its R & D/GNP ratio over the same period, but at a significantly slower rate than the United States. R & D in all nations, including the Soviet Union, appear to be on the rise through the 1980s and into the 90s. The gap is certainly narrowing. But keep in mind the absolute level of R & D funding in the United States is still at a very high level by comparison to other nations.

A second factor is related to the recipient nation's current level of concentration in the relevant industry. In other words, there may be a greater motivation for a country to venture into reverse engineering strategies to imitate a product that could greatly enhance their productivity in a related discipline.

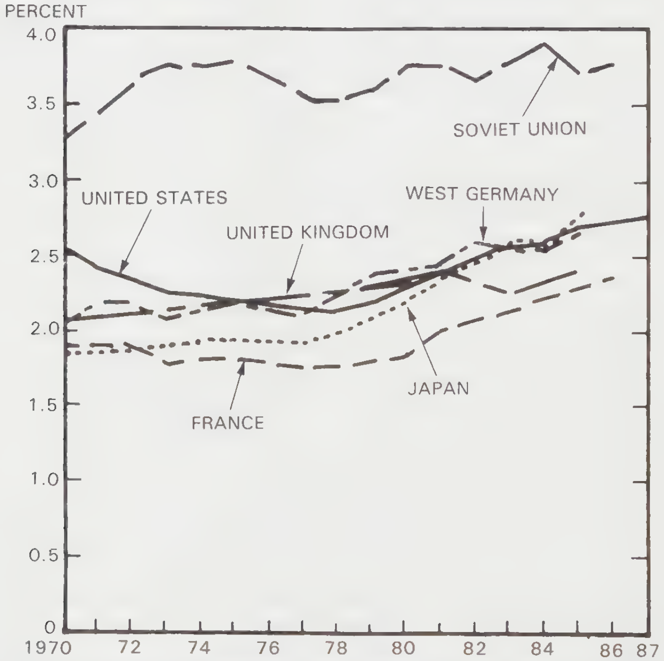

Figure 8.6 "International research and development expenditures as a percentage of GNP" (National Science Board. *Science & Engineering Indicators—1987.* U.S. Government Printing Office.)

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[2] Report of the National Science Board. *Science and Engineering Indicators—1987.* (Government Printing Office, Washington, D.C., 1987).

For example, a country such as Germany may have more interest in robotics technology to assist in the assembly of automobiles than say Spain where the automobile manufacturing industry is not as concentrated. If the recipient country's existing "technology mix" is ripe for the implementation and full utilization of this new technology, there is no question they will place greater emphasis on imitation strategies.

The predominant transoceanic export of American technology, coupled with stronger trends in R & D expenditures in other industrial nations, provide the basic ingredients for reduced imitation lag periods and greater capacities for these countries to be more innovative with reference to technological endeavors. International technology transfer activities will become more complicated as time passes. The presence of a large technology gap between the technology creators and the technology borrowers is becoming less evident. The next section of this chapter focuses on these and other contemporary technology transfer issues through a discussion of the United States' involvement with three separate nations who each aspire to become technological leaders.

CONTEMPORARY TRANSFER SCENARIOS

THE PEOPLE'S REPUBLIC OF CHINA

The People's Republic of China (PRC) is presently embarking on an aggressive journey in the direction of modernization. It seems China is currently very anxious to enter the 20th century before the century runs out! The PRC is on a crash course toward the acquisition of Western technology and know-how as part of its current drive for modernity. While this inevitably will mean considerable business ties for the United States, technology transfer to the PRC contains a number of risks.

The Chinese government is struggling to lessen the economic disasters and social injustices fostered during Mao Tse-tung's "Great Leap Forward" in the 1950s and his "Cultural Revolution" in the 1960s and 70s. In response to these and other social needs, the Chinese Communist Party's central committee adopted a series of sweeping governmental reforms designed to expand foreign trade, import advanced technology, promote international cooperation, and create special economic zones. All of these reforms require a reduction of government centralized planning and control. Some citizens view these efforts to pursue the road of capitalism as an irreverent rejection of socialism. Government leaders seem to believe that the country cannot make the progress it needs to make by following the Soviet model of centralized control within a global economy that emphasizes the industrial sector.

China's modernization efforts hinge on the receipt of technology and expertise. These two elements were deliberately neglected and often punished during Mao's reign. The official party policy recommendations suggest all reforms lead to progress in science and technology, to greater initiative among the localities, and toward making effective use of resident intellectual resources.

The Chinese are undoubtedly quite anxious to speed up their technological development efforts and increase their ability for self-reliance.

Taken as a whole, China's technological base is still relatively backward. The Chinese feel that computers are at the heart of the new host of technologies that will revolutionize their economy. Seventy-five percent of the technology that the Chinese request from the United States is related to electronics and computers including: microelectronic circuitry, electronic instruments, and equipment for producing semiconductors. They want advanced high-speed computers for such areas as meteorological studies, census and demographic surveys, and air-traffic control.

The possibility of military diversion or misuse of these computers is a real concern. Some United States national security experts recommend stricter regulation of technology transfer activities related with the PRC. Of particular apprehension to the military are technologies involving fiber optics and high-speed computers. One of China's import policies states it will not accept any agreement with a technology donor that restricts the end-use of a technology. This seems to leave the proverbial door open for a "revised" application of these "building block" technologies with specific reference to China's defense program.

In light of these recommendations, the People's Republic of China was still granted a Class V status in late 1983 which effected a streamlined review process for sensitive technology being exported from the United States. The "V" category includes most United States allies and friendly non-aligned countries. This reclassification liberalized the technology transfer ventures between the United States and the PRC. Seven technology categories that had previously been "touchy" were included in this liberalization: computers, computerized instruments, microcircuits, semiconductor production equipment, electronic instruments, recording equipment, and oscilloscopes. At present, however, there are still several areas wherein technology transfers can be denied. These are labeled "special mission areas" by the U.S. Department of Defense and include: nuclear weapons, nuclear delivery systems such as ICBMs, antisubmarine warfare, electronic warfare, intelligence gathering, and power projection capabilities such as long-range bombers. In short, advanced military technologies are not to be exported to this nation.

Amid the consternation, China's economic reforms and open-door trade policies will continue to create many business opportunities for firms headquartered in the United States. China plans to direct its efforts toward technical upgrading in all sectors of its society (energy, transportation, education, medicine, telecommunications, automobile, textiles, etc.). Increasingly close relations between the United States and China have created an excellent environment for the natural evolution of technology transfer investments and agreements.[3]

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[3] For further information, contact the Office of China and Hong Kong, U.S. Department of Commerce, Washington, D.C. 20230.

INDIA

The country of India is a sprawling land of contrasts and seeming contradictions. Although India is a developing nation where the economy continues to be heavily dependent on agricultural performance, it is not technologically unsophisticated. It boasts nearly 140 centers of higher learning which graduate the third largest number of scientists and engineers in the world. The technical prowess of these scientists and engineers is evidenced by India's recent accomplishments in nuclear power and space studies. On the flip side however, fifty-five percent of the nation is still illiterate — these individuals are not yet a part of the technological culture forming in their midst.

The vast majority of Indians still reside in villages. The increased mechanization of farms is forcing some inhabitants to seek jobs in the cities. This rural-to-urban migration is placing further strain on government resources that are already inadequate to build the homes necessary to house the villagers. The formation of makeshift shantytowns around industrial plants is the direct result of the lack of subsidized housing, the absence of cheap, reliable transportation, and the dire poverty level surrounding these migrants.

The late 1960s marked the state government's decision to approve the location of a Union Carbide pesticide plant in Bhopal. This city is the capital of India's largest state, Madhya Pradesh. Employment opportunity was one of the driving forces behind this legislative decision. However, the primary motive for this technological transfer was to provide pesticides needed to carry out the green revolution (which was itself a form of innovative technology India was incapable of generating on its own). Less than fifteen years after the site decision was made, a toxic cloud escaped from this Union Carbide plant causing the deaths of at least 2500 residents of the adjacent shantytowns.

Following this disaster, questions regarding the "appropriateness" of this United States multinational firm's transfer of technology were asked again and again. Unlike the United States, India has not yet worked out an environmental standard that applies to hazardous production processes. Health and safety regulations for industrial workers in India are severely outdated and extremely lax by comparison to those heeded in the United States. At the time of the accident, all Bhopal plant managers and workers were Indian nationals. The causal factor for this situation resides in the fact India requires a high national representation at all plants owned by multinational firms in order to assure its technical independence.

Since India is still labor intensive, many jobs automated in the United States are still performed manually in India. For example, safety devices which are automatically monitored at Carbide's plant in Institute, West Virginia, are monitored visually by Bhopal operators. To some extent, these workers received job training based on rote memorization of steps rather than a thorough understanding of the logic behind the procedures. This lack of technical competency may have contributed to the devastating accident at Bhopal. This event was the first time India was forced to come face to face with a large number of deaths in the name of technological development.

Some anthropologists speculate the disaster will slow down India's absorption and wholehearted acceptance of Western technology. Indian embassy officials say the accident will not halt India's acceptance of technology. It will cause the government to more carefully scrutinize the safety of the technology that is being transferred into the country. Both of these perspectives are offered in light of India's obvious enchantment with technology-intensive products and processes.

Rajiv Ghandi became Prime Minister of India in October 1984 and immediately endorsed numerous economic and commercial liberalizations. These policies included lowering taxes, relaxing controls on private economic activity, and opening the economy to more domestic and international competition. India seems to be intent on creating an economic environment that will welcome technology transfer activities and allow business and industry to prosper with less government intervention.

The U.S. Secretary of Commerce met with India's Prime Minister in the Spring of 1985 to focus on the commercial aspects of the U.S./India relationship as they affect the area of high technology transfer. The United States government perceived the need for assurances that sensitive technology is not transferred to unauthorized users or diverted to proscribed countries. These agreements should pave the way for increased trade by accelerating the processing of United States export license applications for India and gradually permitting higher levels of technology to be made available.

Indian trade policies are currently designed to encourage the inflow of selected technologies through licensing arrangements or direct investment. United States firms find such channels for the manufacture of their product in India can serve as an avenue to gain an export market there. In some cases, the item being manufactured under license in India cannot be produced without the import of foreign components from the United States partner. An intergovernmental study was conducted to further analyze opportunities for investment and technology transfer in India.[4] According to these researchers, successful technology transfer ventures depend on such factors as: (1) making a long term commitment to India; (2) conforming to the regulatory framework in India; (3) finding a reputable and compatible business partner to act as a local agent; and (4) building a personal relationship of confidence with this partner.

The dynamic Indian business community coupled with the large Indian market offer enticing investment opportunities for multinationals. The U.S. Department of Commerce lists the following areas as the best prospects for direct exports as well as licensing and joint ventures: oil and gas equipment and services, power transmissions, telecommunications, mining and excavation machinery, computers and peripherals, electronic products and components, machine tools and metal working equipment, printing and graphic arts equipment, medical instruments and health care equipment, and alternate energy equipment.

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[4] India International, Inc. *Doing Business Collaborations in India.* Washington, D.C., 1984.

It remains to be seen whether or not the technology donors will heed the lesson of the Bhopal tragedy concerning transferability and appropriateness. It is easy enough to transfer the hardware into India but next to impossible to impose the regulatory apparatus and Western technological awareness critical for the safe/efficient operation of the hardware.

UNION OF SOVIET SOCIALIST REPUBLICS

It seems the controversial aspects of United States technology transfer activities are most pervasive when the subject of selling technology to the Soviet Union is broached. Should the United States government authorize or even tolerate the sale of technology to a communist country? Should it allow Soviet scientists access to American universities and research materials when these educational endeavors could ultimately be used against us? The most prominent fear among American citizens who oppose technology transfer to the U.S.S.R. is that it will be used to increase Soviet military strength. In the eyes of defense officials, the less technology sold to the Soviet Union the better. Specifically, why should the United States export machine tools that make precision ball bearings when those ball bearings might be used to increase the accuracy of Soviet missiles?

Although the current Soviet "wish list" is replete with high technology products (semiconductor manufacturing equipment, large computers, equipment for making optical devices, etc.), the government's decision to permit the purchase of Western technology is not one that is made without restraint. Soviet officials began to import technology on a broad scale in the 1920s, but U.S. exports were soon curtailed during the Depression. Imports were increased substantially during World War II when the United States was allied with the U.S.S.R. These agreements were virtually ended in the late 1940s with the beginning of the Cold War. After Khrushchev was removed from office in the mid-1960s the import policies changed and Soviet dependence on Western technology increased steadily into the 1980s.

The extent to which the Soviets have become dependent on Western technology in such a short time span indicates an apparent inability to generate high-quality production and innovation from within its current planning and development system. Soviet scientists and engineers are capable of impressive work in their laboratories and on projects related to space and military activities. However, these research efforts seldom find their way into factory-produced consumer goods. Implementing innovations in the Soviet Union takes about twice as long as in the United States since its plant managers are forced to adhere to a system of business plans and targets that stresses quantity rather than quality. In fact, there are incentives to avoid new production processes that may increase quality if their adoption jeopardizes this output even temporarily.

In other words, the Soviets' civilian technological base is significantly weaker than most Americans might realize. For example, information technology is pervasive in the United States lifestyle, but the practical applications within this sector are paltry in the Soviet Union. Even in small rural American towns, supermarkets have installed electronic cash registers that use laser scanners to read prices from universal-product-code labels. Many food stores in the Soviet Union do not even have mechanical cash registers—the clerks use the abacus instead!

This brief discussion of the limitations of Soviet technology is not meant to minimize the concerns expressed by U.S. defense officials. Perhaps it will serve to stimulate your thoughts on the validity of technology transfer phobia presently permeating the media. While the United States government seems interested in improving our trade relations with the Soviets, it continues to employ a large contingent of intelligence experts to stymie the illicit transfer of strategic technology devices and know-how through surreptitious (secret or covert) channels.

For more than twenty years, Warsaw Pact nations have mounted a coordinated, deliberate program to buy or steal United States technology. Typically, the desired equipment (most often electronic/computer related) is purchased by an unscrupulous middleman in a NATO country and then reshipped illegally to one or more dummy companies in other countries in order to confuse or cover the trail. It ultimately ends up in a neutral country such as Austria, Liechtenstein, Sweden, or Switzerland, where it can be freely shipped to eager technology purchasers in the Eastern bloc. In many instances, the receipt of proven Western technologies has saved the Soviets huge research expenses and years of developmental exercises in the form of trial and error research projects. Intelligence experts in the United States Defense Department claim these strategic acquisitions have enabled the Soviets to narrow their technology gap with the United States from ten years to as little as two years. It seems a majority of Russia's most advanced military weapons incorporate technology initially pirated from the West.

It is likely the Soviets will continue to seek imported technology to assist them in the modernization of their economy. It is also probable some of this imported technology, whether it be purchased or stolen, will increase the strength of the communist bloc. The proponents of increased technology transfer agreements between the United States and the U.S.S.R. suggest our emphasis should be on increasing the international flow/global exchange of technology and innovations. This increased activity will permit us to stay a generation or two ahead of Soviet technology. Trade restrictions related to technology-intensive products may be more harmful to the United States than previously envisioned. We have possibly impaired our relations with our allies as much as we have had an adverse effect on the Soviet Union.

SUMMARY

There are many types of technology transfer agreements which occur on an international scale. Most of these involve some form of horizontal transfer of a new material or product, design specifications, or capacity for production from one organization (nation) to another. Transfer agreements typically consist of a technology donor and a technology recipient who rely on a variety of channels for the linkage to take place. A few of the formal channels for transfer include foreign direct investment, turnkey plants, licensing, and the export of manufactured goods. An assortment of noncommercial transfer channels also permit the effective exchange of technological information and expertise among world nations.

A comprehensive assessment of the "transferability" and "appropriateness" of the technologies being considered should always precede transfer investments. Current technology transfer interactions between the United States and the People's Republic of China, India, and the Soviet Union illustrate many of these principles. These three nations were selected for review in that they accurately reveal the fact the contemporary international technology transfer network is characterized by numerous technical complications as well as a great many beneficial settlements and transactions.

DISCUSSION QUESTION

1. Provide a general definition of the term "technology transfer." Give several contemporary examples that serve to illustrate your explanation of this concept.
2. What are the key elements used to conduct a comparative analysis of the activities associated with international technology transfer?
3. What strategies and procedures are United States manufacturers of high technology products using to prevent or deter the process of "reverse engineering?"
4. Explain the difference between foreign direct investment and licensing as they are currently used to transfer technology from one country to another. Provide contemporary examples of each transfer channel.
5. Speculate on the causal factors that may be responsible for intermittent declines in the United States share of high technology exports.
6. Define the term "appropriate technology" and discuss several examples which illustrate its presence or absence in your current living arrangement or daily routine.
7. Select a foreign nation other than those discussed in this chapter and develop a profile of its current involvement with the United States with reference to technology transfer activities.

SUGGESTED READINGS FOR FURTHER STUDY

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Chapter 9

GLOBAL ENERGY RESOURCES

DATELINE

Detroit, Michigan

American automotive engineers and industrial designers have begun to realize that rain can teach us how to build more energy efficient cars. A simple raindrop that is three times longer than it is wide is the most aerodynamic shape in nature. It has a coefficient drag (Cd) of .04. Cd is a mathematical expression of how easily an object like an automobile slips through the air. The more easily your car coasts through the air, the less money you'll spend on gasoline since it takes less energy to move the vehicle. Drag increases with the square of the velocity. As you double your speed, let's say from 25 miles an hour in a residential section of town to 55 miles an hour on the interstate, air drag increases four times.

The average full-size American car has a Cd of 0.45; a barn door has a Cd of 1.17; a bird has a Cd of 0.30 while a bullet has a Cd of 0.25. How can today's designers reduce drag and make our automobiles more like bullets and less like barn doors? They must ultimately manage the flow of air around the car by changing its shape. Like the raindrop, energy efficient automobiles should have smooth rounded corners and soft edges. We seem to be making some headway in this direction—the federal government approved styled head-lamps a few years back making it possible to blend the headlamps into the shape of the fenders . . . .

INTRODUCTION

Quite simply, ENERGY is the capacity to do work. Contemporary society derives the energy it requires from a large variety of sources. "Energy" didn't really seem like a global issue until the early 1970s with the Arab oil embargo. At that instant, the phrase "energy crisis" quickly started to dominate media headlines around the world. Soon after that, consumers became accustomed to hearing about a series of energy-related topics. Manufacturers marketed their products as being "energy efficient." Political leaders encouraged us to turn our thermostats down and become "energy conscious" citizens. In the same breath, they promised us that the United States would one day become an "energy independent" nation. International conferences and workshops convened to formulate "energy policies" devoted to the spirit of global cooperation. Energy users were applauded when they conserved energy and reprimanded when they wasted it. The 1970s can therefore be described as a decade in which energy issues permeated the very fabric of our social consciousness.

In recent years, some of these sentiments seem to have faded significantly due to more favorable news concerning an apparent surplus of oil. The "so-called" oil glut of the mid-1980s resulted from a combination of reduced demand for oil and increased oil production by non-OPEC (Organization of Petroleum Exporting Countries) nations, especially Mexico and Great Britain. A worldwide recession was partially responsible for the reduction in demand. It follows that the demand for oil will gradually pick up as global economic activities increase over the next several years.

Unfortunately, the "so-called" glut diverted our attention away from the longer-term problem of developing new energy sources. A large percentage of consumers seem to be so relieved to see gasoline prices stabilize somewhat that they can not take time out to worry about events which might take place during the next ten to fifteen years.

The search for energy has been of paramount (supreme) importance to civilization since ancient times. Energy permeates all aspects of our environment. The threat of short-term physical energy "shortages" coupled with the perception of an underlying long-term energy "problem" have molded this issue into a clear and present social and technological condition. For some people, ameliorating (improving) the energy problem means enhancing our supply levels. For others, the solution to the energy problem warrants an overall reduction in demand. In either case, it seems the world is in the midst of an energy system transition. Political leaders are progressively beginning to accept the fact that the current dominant position of conventional oil and natural gas in the world's energy sector must sooner or later give way to other energy sources.

In order to make an intelligent assessment about whether or not there really is an impending energy crisis and the extent of its severity, we must possess some insight into what might be called the "global energy system." An understanding of energy systems requires an understanding of resources and the technologies related to their efficient utilization. An energy system consists of a set of operational elements and a resultant pattern of interactions among them.

To evaluate energy systems in known physical terms, the basic elements identified might include oil wells, coal mines, nuclear reactors, gasoline burning automobiles, and electric irons. Further, interactions within the energy system could be depicted as highways, pipelines, and electric grids.

The functional elements of an energy system are PRODUCTION and CONSUMPTION. The interactions between these two sides are called DISTRIBUTION. Energy actors are therefore labeled producers (OPEC), consumers (e.g., automobile owners), or distributors (public utilities). Economists who regularly attempt to make forecasts about the critical aspects of the world's various energy systems tend to focus primarily on supply (production) and demand (consumption).

The contemporary energy system is, in every sense of the word, a global system. An automobile owner almost anywhere in the world, who pulls into a gas station to fill his or her tank, could be purchasing energy which originated in the Middle East, Africa, Latin America, Asia or even the United States. This chapter presents a universal perspective of the world's present energy picture. Energy supplies and the parallel demands for them are viewed as key issues in the international political arena. Energy forms are distinguished as being nonrenewable, renewable, or eternal.

The First Law of Thermodynamics asserts the total amount of energy in the universe is fixed. It can, however, be changed into other forms. For instance, the chemical energy in a piece of coal is transformed into the heat energy of a flame, part of which is turned into the kinetic energy of motion in a steam engine, and so forth. In addition to the chemical energy stored in fossil fuels, nature provides useful energy in many different forms. Wind and waves provide kinetic energy. Potential energy exists in the damned up waters of a lake. When the water is allowed to flow down to a lower level, an equivalent amount of mechanical energy can be generated in a turbine. This will produce electrical energy that is transported via conducting cables to load centers for distribution. The radiant energy of sunlight can be converted into chemical energy by photosynthesis or into electrical energy by photovoltaic devices. And finally, nuclear energy is released by changing the atomic structure of the nuclei of certain natural elements.

Considering these examples, is there an energy shortage? Is the world truly running out of energy? The answer to these questions may be an honest "no!" On the other hand, they may not be the right questions to ask. Perhaps the inquiry we should be called upon to ponder is this: Are there sufficient energy resources available to meet our present and expected future demands in a form that we can utilize and at a price we can afford? Obviously, the key words are "form" and "price." The current global energy profile must be studied from these vantage points. Price includes environmental costs as well as dollar expenditures. Form is directly related to consistency of availability, the extent to which amounts are finite, and the technologies associated with their extraction, access, and conversion.

1. Who are the central actors in today's dynamic international drama of energy politics?
2. What sorts of energy sources should be explored or encouraged and developed within specific countries? Why might a particular energy form

be considered more suitable for one sector of the world's civilization vs. another?

3. Can the risks and costs of nuclear energy be reduced to a level acceptable to all social groups? How should we go about weighing the risks of future climate changes against the low cost and comparatively high availability of coal?
4. How can renewable energy sources best be integrated into our existing energy system?
5. What strategies will be most effective to stimulate long-term "conservationist" attitudes with regard to energy use and consumption among the world's populations?

KEY CONCEPTS

The following list of terms and phrases will be introduced and discussed in the following pages. You should attempt to gain an understanding of their meaning as you read through this material devoted to energy resources.

OPEC
Proven Reserves
"Yellow Cake"
IAEA
Biomass Energy
Kinetic Energy
Photovoltaic Cells
IEA
Fuel Cell
Breeder Reactor
Tidal Power
Potential Energy

INTERNATIONAL ENERGY POLITICS

Those members of society residing in high technology population centers often seem to take energy for granted. The midwestern U.S. salesperson *expects* to be able to exit off the interstate to fill the gas tank of her company car and be back on the road in less than ten or twelve minutes. The German technical writer *expects* to have no interruptions in electrical power while she keyboards a document onto the hard disk of her personal computer. The Canadian restaurant owners *expect* to witness a normal (and profitable) weekend evening of dinner service out of their modern, energy-intensive kitchen. These "behind-the-scenes" glimpses at contemporary lifestyles seem rather ordinary. Not one of them is really deserving of special notice. The truth of the matter is that most of us use energy throughout the day, every day, without a second thought about its origin or the reliability of its presence.

When you enter into a darkened room, your most likely first impulse is to grope around for a light switch. Chances are, if this search takes longer than 10-20 seconds, you will probably leave the room to find an alternative light source to assist you. Once you manage to find the switch, flipping it should result in what? Certainly not continued darkness! This very isolated story illustrates the simple fact we are an energy-oriented and an energy-dependent society. Still, we rarely stop to think about energy's link to our economy, our technological well-being, and to the general character of our life process.

The global energy realities which have emerged during the past two decades are difficult to ignore. A large portion of the economic issues being examined by today's leading socioeconomic commentators relate to the world's energy situation. Social forecasters never miss the chance to mention the future of the world's energy resources. Several of them tell us that, sometime near the turn of the century, the world's crude oil production will peak. This eventuality is the ultimate fate of every non-renewable resource. When that time comes, the energy scene will never be the same as we know it right now.

Regardless of how large the numbers listed in the chart in Figure 9.1 might seem, you must remember that they are finite. "Proven" world reserves refer to both crude oil and natural gas reserves definitely known to exist and are also recoverable under current economic conditions. Finite resources will not last forever. In the absence of a major effort to anticipate the peaking of global oil production, consuming nations will find themselves confronting declining supplies and skyrocketing prices. The resulting strains on international diplomacy might create just the stimulus needed for widespread economic disaster and military confrontation.

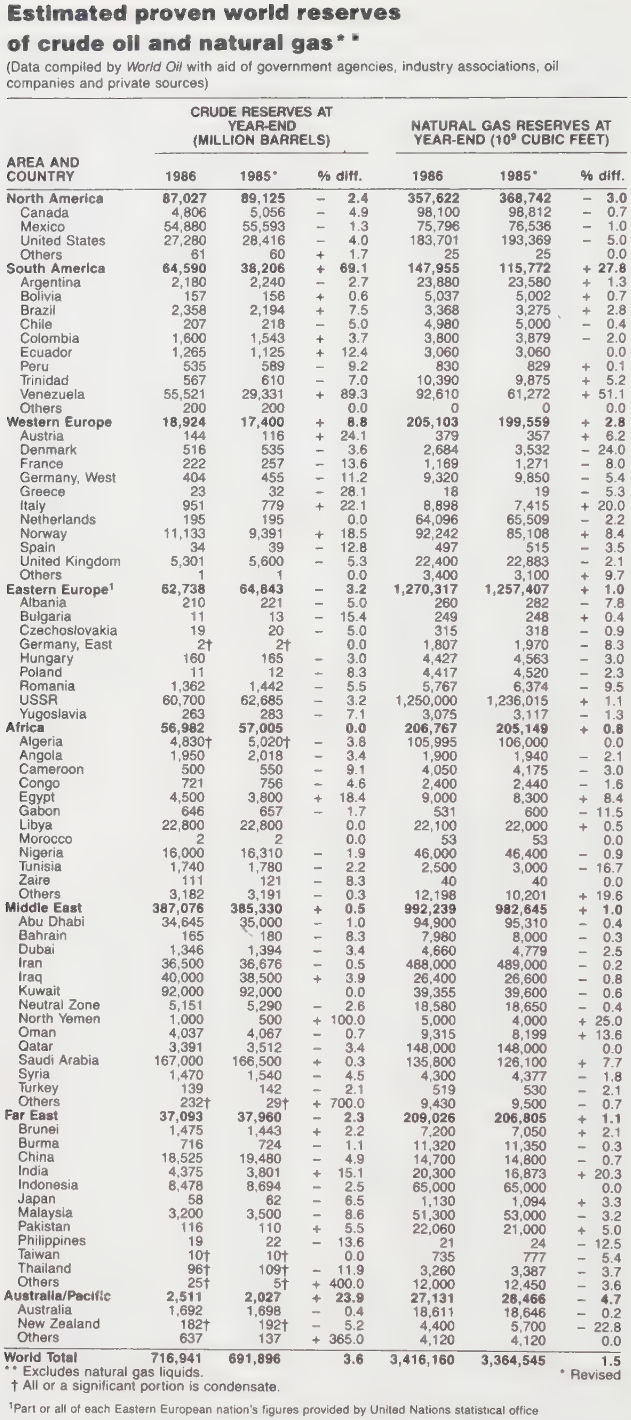
The world's energy situation is often times incomprehensible. Energy is a vital interest to most industrial nations, as well as to those that are still developing. Energy politics, on the other hand, seem to create trauma and ill feelings among all the participants in the exchange. The roles played by these energy system actors seem to reflect the political complexities of an international network that is highly unstable and fragmented in its long-term policies and expected outcomes.

ACTORS ON THE ENERGY SYSTEM STAGE

The leading roles on the contemporary international energy scene are held by actors who fall into one of three general categories: nation-states; international governmental organizations; and international non-governmental organizations. Each of these structural classifications consists of groups that perform a range of energy policy functions. As mentioned earlier, the global energy system contains three main functional elements including: production, distribution, and consumption.

The PRODUCTION FUNCTION is the chain of events during the process of converting a physical resource base into a useful energy source. The first stage revolves around exploratory activities when the resource base is discovered, delimited (boundaries defined), and sampled. Stage two may be called extraction when the resource is actually removed from the earth. The final stage involves upgrading, refining, and processing the resource to make it useful to society. The DISTRIBUTION FUNCTION is the movement or transportation of energy sources among the various stages of production and finally to the ultimate user. The CONSUMPTION FUNCTION refers to the end-use of the energy source.

To illustrate these functional roles and responsibilities, consider the use of



Estimated proven world reserves of crude oil and natural gas**

(Data compiled by *World Oil* with aid of government agencies, industry associations, oil companies and private sources)

AREA AND COUNTRY	CRUDE RESERVES AT YEAR-END (MILLION BARRELS) 1986	1985*	% diff.	NATURAL GAS RESERVES AT YEAR-END (10^9 CUBIC FEET) 1986	1985*	% diff.
North America	**87,027**	**89,125**	**– 2.4**	**357,622**	**368,742**	**– 3.0**
Canada	4,806	5,056	– 4.9	98,100	98,812	– 0.7
Mexico	54,880	55,593	– 1.3	75,796	76,536	– 1.0
United States	27,280	28,416	– 4.0	183,701	193,369	– 5.0
Others	61	60	+ 1.7	25	25	0.0
South America	**64,590**	**38,206**	**+ 69.1**	**147,955**	**115,772**	**+ 27.8**
Argentina	2,180	2,240	– 2.7	23,880	23,580	+ 1.3
Bolivia	157	156	+ 0.6	5,037	5,002	+ 0.7
Brazil	2,358	2,194	+ 7.5	3,368	3,275	+ 2.8
Chile	207	218	– 5.0	4,980	5,000	– 0.4
Colombia	1,600	1,543	+ 3.7	3,800	3,879	– 2.0
Ecuador	1,265	1,125	+ 12.4	3,060	3,060	0.0
Peru	535	589	– 9.2	830	829	+ 0.1
Trinidad	567	610	– 7.0	10,390	9,875	+ 5.2
Venezuela	55,521	29,331	+ 89.3	92,610	61,272	+ 51.1
Others	200	200	0.0	0	0	0.0
Western Europe	**18,924**	**17,400**	**+ 8.8**	**205,103**	**199,559**	**+ 2.8**
Austria	144	116	+ 24.1	379	357	+ 6.2
Denmark	516	535	– 3.6	2,684	3,532	– 24.0
France	222	257	– 13.6	1,169	1,271	– 8.0
Germany, West	404	455	– 11.2	9,320	9,850	– 5.4
Greece	23	32	– 28.1	18	19	– 5.3
Italy	951	779	+ 22.1	8,898	7,415	+ 20.0
Netherlands	195	195	0.0	64,096	65,509	– 2.2
Norway	11,133	9,391	+ 18.5	92,242	85,108	+ 8.4
Spain	34	39	– 12.8	497	515	– 3.5
United Kingdom	5,301	5,600	– 5.3	22,400	22,883	– 2.1
Others	1	1	0.0	3,400	3,100	+ 9.7
Eastern Europe[1]	**62,738**	**64,843**	**– 3.2**	**1,270,317**	**1,257,407**	**+ 1.0**
Albania	210	221	– 5.0	260	282	– 7.8
Bulgaria	11	13	– 15.4	249	248	+ 0.4
Czechoslovakia	19	20	– 5.0	315	318	– 0.9
Germany, East	2†	2†	0.0	1,807	1,970	– 8.3
Hungary	160	165	– 3.0	4,427	4,563	– 3.0
Poland	11	12	– 8.3	4,417	4,520	– 2.3
Romania	1,362	1,442	– 5.5	5,767	6,374	– 9.5
USSR	60,700	62,685	– 3.2	1,250,000	1,236,015	+ 1.1
Yugoslavia	263	283	– 7.1	3,075	3,117	– 1.3
Africa	**56,982**	**57,005**	**0.0**	**206,767**	**205,149**	**+ 0.8**
Algeria	4,830†	5,020†	– 3.8	105,995	106,000	0.0
Angola	1,950	2,018	– 3.4	1,900	1,940	– 2.1
Cameroon	500	550	– 9.1	4,050	4,175	– 3.0
Congo	721	756	– 4.6	2,400	2,440	– 1.6
Egypt	4,500	3,800	+ 18.4	9,000	8,300	+ 8.4
Gabon	646	657	– 1.7	531	600	– 11.5
Libya	22,800	22,800	0.0	22,100	22,000	+ 0.5
Morocco	2	2	0.0	53	53	0.0
Nigeria	16,000	16,310	– 1.9	46,000	46,400	– 0.9
Tunisia	1,740	1,780	– 2.2	2,500	3,000	– 16.7
Zaire	111	121	– 8.3	40	40	0.0
Others	3,182	3,191	– 0.3	12,198	10,201	+ 19.6
Middle East	**387,076**	**385,330**	**+ 0.5**	**992,239**	**982,645**	**+ 1.0**
Abu Dhabi	34,645	35,000	– 1.0	94,900	95,310	– 0.4
Bahrain	165	180	– 8.3	7,980	8,000	– 0.3
Dubai	1,346	1,394	– 3.4	4,660	4,779	– 2.5
Iran	36,500	36,676	– 0.5	488,000	489,000	– 0.2
Iraq	40,000	38,500	+ 3.9	26,400	26,600	– 0.8
Kuwait	92,000	92,000	0.0	39,355	39,600	– 0.6
Neutral Zone	5,151	5,290	– 2.6	18,580	18,650	– 0.4
North Yemen	1,000	500	+ 100.0	5,000	4,000	+ 25.0
Oman	4,037	4,067	– 0.7	9,315	8,199	+ 13.6
Qatar	3,391	3,512	– 3.4	148,000	148,000	0.0
Saudi Arabia	167,000	166,500	+ 0.3	135,800	126,100	+ 7.7
Syria	1,470	1,540	– 4.5	4,300	4,377	– 1.8
Turkey	139	142	– 2.1	519	530	– 2.1
Others	232†	29†	+ 700.0	9,430	9,500	– 0.7
Far East	**37,093**	**37,960**	**– 2.3**	**209,026**	**206,805**	**+ 1.1**
Brunei	1,475	1,443	+ 2.2	7,200	7,050	+ 2.1
Burma	716	724	– 1.1	11,320	11,350	– 0.3
China	18,525	19,480	– 4.9	14,700	14,800	– 0.7
India	4,375	3,801	+ 15.1	20,300	16,873	+ 20.3
Indonesia	8,478	8,694	– 2.5	65,000	65,000	0.0
Japan	58	62	– 6.5	1,130	1,094	+ 3.3
Malaysia	3,200	3,500	– 8.6	51,300	53,000	– 3.2
Pakistan	116	110	+ 5.5	22,060	21,000	+ 5.0
Philippines	19	22	– 13.6	21	24	– 12.5
Taiwan	10†	10†	0.0	735	777	– 5.4
Thailand	96†	109†	– 11.9	3,260	3,387	– 3.7
Others	25†	5†	+ 400.0	12,000	12,450	– 3.6
Australia/Pacific	**2,511**	**2,027**	**+ 23.9**	**27,131**	**28,466**	**– 4.7**
Australia	1,692	1,698	– 0.4	18,611	18,646	– 0.2
New Zealand	182†	192†	– 5.2	4,400	5,700	– 22.8
Others	637	137	+ 365.0	4,120	4,120	0.0
World Total	**716,941**	**691,896**	**3.6**	**3,416,160**	**3,364,545**	**1.5**

** Excludes natural gas liquids.

† All or a significant portion is condensate.

* Revised

[1] Part or all of each Eastern European nation's figures provided by United Nations statistical office

Figure 9.1 International proven oil and natural gas reserves. (World Oil)

coal as an energy source. Its production phase includes drilling exploratory core holes, extracting the coal through either surface or underground mining, and processing it through a series of cleaning procedures. See Figure 9.2. Its distribution is most commonly accomplished via the railroad, but other transport modes may be more appropriate for shorter distances. Coal consumption extends across a range of end-use activities. Coal may be burned in a boiler in its solid form or converted to a liquid form for applications in newer synthetic fuel technologies. The next sections provide a brief description of several energy actors and the functions they seem anxious to play in the current round of global energy politics.

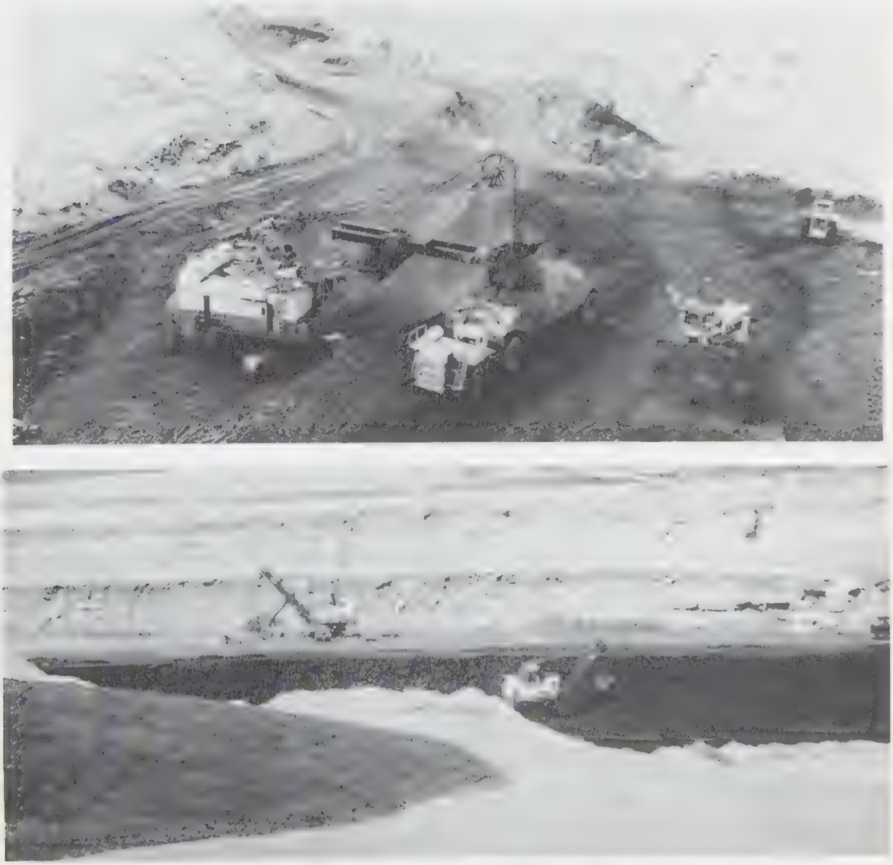


Figure 9.2 Surface coal mining in the United States. Top. A loading shovel and a front end loader scooping up coal to drop it into a truck at Peabody Coal Company's Black Mesa mine in Arizona. Bottom. After coal is removed, disturbed land is leveled and reclaimed. AMAX Coal Company's Belle Ayr mine near Gillette, Wyoming is the largest producing coal mine in the United States. This view of Belle Ayr shows the active mining process with new and more advanced reclamation of the land in the foreground. (National Coal Association)

NATION-STATES

National actors are important as both producers and consumers of energy. They are generally classified according to whether they are net producers or consumers of energy (net exporters or importers). Saudi Arabia is the current dominant force in energy production in the Middle East. Since the United States consumes nearly one-third of the world's energy, it exercises a considerable amount of influence over global energy consumption patterns. For obvious reasons, these two rational actors, plus two others who are less visible but not less active, deserve our attention.

Saudi Arabia

The Saudi Arabia oil fields contain a heavy percentage of the proven oil reserves found outside the communist world. The Saudi position in international energy affairs has been realized via authoritarian rule within a traditional kinship society. The Saudis have used their oil production prowess (extraordinary ability) not only for economic gain, but also as a political weapon in the ongoing conflicts in the region.

Up through the mid-1980s, Saudi Arabia acted as the mainstay of OPEC. They actively supported the cause for price stability. When supplies were tight during the 1970s, the Saudis placed their formidable weight on the side of price moderation. By the early 1980s, the situation had reversed and prices were threatened by oversupply. The Saudis subsequently appointed themselves as the swing producer within OPEC and agreed to cut back their production as necessary to maintain the agreed upon price structure.

Within a few recession-plagued years, it became apparent the role of swing producer (which had been adopted as a short-term expedient to adjust for seasonal variations in demand) had become a recipe for national extinction. As Saudi Arabia cut back its production, other OPEC members as well as non-OPEC producers continued to increase their revenues. Saudi leaders made a very bold decision at this point. Saudi Arabia had sacrificed for the market and now the market would be sacrificed for them. This decision to break their self-imposed OPEC production ceiling signaled another price war and an "oil glut." Saudi reserves in the mid-1980s were estimated at one quarter of the world's total. (Some believe that even this estimate is conservative and possibly understated.) It appears that at the single turn of a valve, the Saudis still have the power to shut off wells to make prices rise, or flood the market with crude to make prices fall. This reality is likely to remain unchanged for the next several years.

United States

The United States is another leading producer of energy. However, its seemingly unlimited consumption appetite makes it a pivotal actor in international energy politics. Since the end of the second World War, its production and consumption practices have gradually grown out of balance. Its citizens have reached a point where they have become dependent on the least abundant United States resources to provide a majority of their energy supplies. The major price shocks of the 1970s forced the United States government to devise an energy policy directed at energy independence. The aim was reduced dependence on oil imported from OPEC and the highly unstable Middle East.

The Carter administration's implementation of the National Energy Plan in the late 1970s did a number of things.

1. It established the Department of Energy.
2. It ordered the utilization of government subsidies, tax policy, and direct outlays to increase the production of domestic energy supplies.
3. It promoted the expansion of efforts to encourage energy conservation.
4. It designed a rational pricing policy for depletable oil and natural gas involving a gradual deregulation of prices. This program was loaded with controversy, but it did manage to chart an energy policy for the nation.

The direction of this plan changed drastically with the inauguration of the Reagan administration in the early 1980s. Expenditures and manpower for conservation projects and renewable energy programs were severely curtailed. The United States adopted a market-based solution to address its energy problems. Since the early 1980s, efforts have focused on the expansion of the nation's fossil fuel inventory.

The United States continues to conduct its industrial technology oriented lifestyle as a petroleum-dependent entity. Some economic observers in the oil industry project the United States is facing an inevitable national catastrophe. Consumers seem to be trading short-term price benefits for long-term energy security. Many people may not even realize a trade is being made. The difficult transition from an oil/natural gas energy system to one that derives power from a variety of conventional and alternative sources has not yet made much headway in this country. In light of that fact, another energy crisis may be upon its residents in the very near future.

Mexico

This North American nation is a relatively recent actor in the oil production arena. Its proven reserves of crude oil are quite significant (approximately 25-30 percent of that found in Saudi Arabia) and may have a dramatic effect on the future of the world's oil picture. Mexico has embarked on a cautious and deliberate oil resource development strategy.

Current Mexican oil policy first emphasizes domestic economic development and limits the amount of crude the state oil company (Pemex) can export. The second pillar of this country's oil policy says that no buyer (for example, the United States) is allowed to take more than one half of the total exports. The third pillar of its oil policy was overthrown in the mid-1980s when domestic product prices were sharply increased. The added income enabled Pemex to insulate its energy and power budget from international market forces, but Mexican consumers paid higher prices to satisfy their personal energy needs.

A number of non-energy issues have recently clouded Mexican-American discussions regarding possible linkages between Mexico's promising production potential and the United States oil market. More restrictive American immigration legislation and water resource decisions are two prime examples of bargaining issues. These issues may spell long-term frustration as the negotiations regarding United States and Mexican energy arrangements continue to unfold.

Japan

This high-technology nation imports four-fifths of its energy. It has reduced the volume of its oil imports by 26 percent since the early 1970s. On the other hand, a majority of the oil it still imports comes to Japan through the turbulent middle eastern waters. Japan's energy policies are neatly dovetailed with its industrial ventures. A sleeker iron and steel industry consumes only one-quarter of the oil it did at the time of the Arab oil embargo. Its cement industry has converted entirely to gas and coal. The energy efficiency of consumer products like automobiles and appliances has improved dramatically. Japan presently uses less energy per unit of output than any other large industrial nation-state.

Japan's energy policy is coordinated by the Ministry of International Trade and Industry (MITI). This group provides financial assistance to the big energy consumers who are also known as energy management factories. These companies employ full-time energy managers to track down waste in the plants. Tax savings and low interest loans are incentives for companies to invest in energy-conservation equipment. MITI invests heavily in energy research. Current projects in Japan involve high-efficiency heat pumps, fuel-cell technology, and the development of solar and geothermal power sources.

ORGANIZATION OF PETROLEUM EXPORTING COUNTRIES (OPEC)

OPEC is an example of an international governmental organization. At the present time, its membership consists of thirteen countries which together produce nearly 80 percent of the crude oil in world trade. OPEC includes the following nations listed alphabetically: Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela. This organization was founded in 1960 as a response to reductions in the posted price of crude oil by the world's petroleum multinational corporations.

OPEC was initially characterized as an international government organization which only reacted to changes as they occurred. It was not conceived to bring about modifications in the global energy system. Since its inception, the oil cartel has evolved into a strong energy actor. It has maintained a flexible structure able to withstand, for the most part, serious tests of its political consensus. OPEC has continually focused its internal efforts on the issues surrounding petroleum pricing. The cartel's success for nearly three decades has been due to its physical and economic capabilities to constrain production. The overall political stability of the cartel remains tentative.

The U.S. State Department considers OPEC to be the greatest problem in the oil business. This is not surprising! Government officials believe market forces, and not OPEC producers, should control oil markets and determine prices. The United States opposes OPEC and other cartels because they restrain more creative trade agreements. OPEC may be able to once again display its former solidarity, but it presently seems to be trying to re-group and re-establish itself.

INTERNATIONAL ENERGY AGENCY (IEA)

The IEA is another example of an international governmental organization. Founded in 1974, it has essentially the same membership as the Organization for Economic Cooperation and Development (OECD). The IEA provides a vehicle for cooperative oil sharing and demand restraint. Much of the IEA's early efforts centered on the establishment of agreements on floors to be placed under oil prices. They believed individualized national efforts to encourage private production might be undercut by a sudden drop in OPEC prices. By the late 1970s, the IEA reached an agreement on automatic sharing of available oil supplies in the event of future shortages.

The longer-term goals of IEA are to encourage conservation, cooperative research and development programs, and the implementation of broader energy policy principles. Participating members have agreed the agency should conduct regular systematic reviews of each country's energy policy. Generally speaking, IEA seems to be advocating a dedicated commitment among the industrialized nations of the world to conserve energy and strategically develop alternatives to oil as their primary source of energy.

MULTINATIONAL BUSINESS ENTERPRISES

OPEC and IEA are undoubtedly more visible and perhaps more easily described than other participants. However, there are a few international non-governmental organizations which continue to exert a fair amount of influence in the establishment and execution of energy policies. The most significant types of socio-business entities in this category of energy actors include multinational energy firms and global environmental groups. The latter have played a crucial role in spearheading international resistance to such energy projects as the approval of nuclear power plants. Friends of the Earth is one of the more verbal environmental organizations with regard to international energy policy and has active membership branches around the world.

Multinational corporations have been in the forefront of international oil policy from the earliest days of the development of petroleum resources. Several oil multinationals (Exxon, Mobil, Standard of California, and British Petroleum) are among the world's largest and most profitable corporations. These companies and others like them are typically characterized by relatively constant economic stability, large capital resources, and extensive research and development capabilities to explore new science and technology.

The staggering economic strength of the international oil majors led to fears that they could too easily manipulate energy supplies, prices, and alternative resource development projects. Subsequently, many industrialized nations applied regulatory policies to the oil industry. More significantly, the producer governments asserted their control over crude oil production and price ceilings. As a result, the distribution function of the multinationals involved in the world's energy system has become more significant than their earlier emphasis on production management. Other noteworthy changes in the energy industry have been related to the recent growth of conglomerates that control a multiplicity of energy resources (coal and uranium mines in addition to oil wells).

Regardless of their relative size or structural position, all types of energy actors enter into the policy limelight to achieve specific objectives. OPEC nations meet on a regular basis to determine new crude oil pricing and to adjust production rates. The United States sells military equipment to countries like Saudi Arabia to insure its future energy security. Environmental groups endeavor to protect the ecosystem by lobbying for legislation to regulate ecologically threatening activities (strip mining for coal, nuclear waste disposal). The oil majors seek to increase their profits. Consumers try to find the lowest prices for gasoline at local service station pumps. In each example, an energy actor is participating in an activity that may or may not lead to the attainment of a valuable goal. In the volatile world of energy politics, it is commonly the contradiction among such values that creates conflict among the most influential energy system actors.

NUCLEAR ENERGY UNDER SCRUTINY

Assume for a moment you have been invited to comment on the use of nuclear power technology to meet the world's current energy needs. Without a doubt, you would be hard pressed to respond to this invitation without pondering the topic of nuclear reactor accidents. In less than a decade, the devastating events that took place first in the United States (Three Mile Island, March 1979) and later in the Soviet Union (Chernobyl, April 1986) shook society's faith in this form of energy production. At present, the pros and cons of the nuclear option are being debated by most of the world's industrialized nations.

The challenge to make nuclear energy production safer is extremely broad. Aside from the danger of accidents, the normal operation of nuclear power plants presents a series of problems. One entails the management of materials like plutonium and weapons-grade enriched uranium. The possible diversion of these fuels for non-peaceful use by other nations and terrorists is sufficient cause for alarm. There is also the possibility the power plants could be sabotaged or subjected to an aggressive military attack. Scientists conclude the potential damage from such actions would involve radiological consequences far worse than those witnessed in the aftermath of the Chernobyl accident.

International institutions have not been ignorant to the types of challenges posed by the more than 380 commercial nuclear reactors presently operating in over 25 nations. Worldwide nuclear standards are emerging that we hope will ultimately be suitable to treat each type of risk in a distinct and efficient manner. One of the few beneficial after-effects of the tragic occurrence at Chernobyl may be a renewed international willingness to cooperate on nuclear safety issues. The accident further presents larger questions regarding the future of the entire nuclear power industry and the means through which its standards can be enforced.

The first independent experts commissioned by the Soviets to investigate the damaged Chernobyl reactor were representatives from the International Atomic Energy Agency (IAEA). Since the early 1960s, the IAEA has been actively involved in the following:

1. Setting up international nuclear safety standards.
2. Drawing up codes and operational guidelines.
3. Promoting the exchange of safety information.
4. Fostering nuclear energy research projects..

It has also been helping Third World and smaller European countries to contend with their own safety problems and to prepare for possible nuclear emergencies. By the late 1970s, the agency began to formalize these measures in a comprehensive body of Nuclear Safety Standards. Items on the list ranged from recommendations to governments about effective national structures to ensure nuclear safety to guidance on selecting appropriate reactor sites.

IAEA presently operates with a 35-member board of governors, including representatives from most leading industrialized and developing countries concerned about the effective use of nuclear power. The Three Mile Island accident prompted member governments to agree to an international "Incident Reporting System." This program was designed to record and analyze the numerous mishaps, most of which are minor, that occur at nuclear plants. It was never intended to serve as an early warning mechanism.

The IAEA's standards are recommendations which governments may adhere to on a voluntary basis. One rare exception to this practice exists where the agency actually helps to build the nuclear station or directly provides the atomic fuel. IAEA safety missions are sent out upon specific government request. For the most part, information exchange, participation in research, and compliance with the incident reporting system are purely unprescribed. Some of these operating procedures may change in the next several years as a result of the Soviet reactor calamity.

It has been suggested that IAEA's nuclear safety standards no longer be mere recommendations. In other words, the agency should enforce the standards by conducting routine safety inspections. This feat of periodic inspection of close to 400 operational nuclear power reactors around the world would require a massive transfer of resources and authority to the IAEA from its member states. These transfers have not yet been sought. It is unlikely they would be approved by all members. On a different tack, if governments can bind themselves to give early warning and to coordinate their responses to emergencies, it seems plausible they will soon agree to self-enforcement procedures with respect to international nuclear safety principles.

CURRENT STATUS OF THE NUCLEAR OPTION

Nuclear power is the youngest member of the world's major energy sources. The combustion of fossil fuels, biofuels, and even the often referenced renewables have been understood and used for centuries. Conversely, the notion that the energy locked in the nucleus of an atom could be released and harnessed for practical purposes only began to make sense in the 1930s. Even then, the means of accomplishing the reaction was not yet apparent. Nuclear fission reactors became a reality in the early 1950s. The technology is now established as a significant contributor to the world's energy network.

Nuclear power is pretty good at producing large quantities of electricity. Barring a huge shift in the world's current pattern of energy consumption, nuclear power is the form of energy that will be most in demand if economic growth is to be maintained. Most of the world's nuclear plants which have gone into operation over the past two decades have demonstrated the ability of nuclear power to generate relatively inexpensive electricity. An industrial survey of United States utilities in the early 1980s found the average cost of generating a kilowatt-hour of electricity with nuclear energy was 10 percent cheaper than coal, and less than half as expensive as oil.

The scale of nuclear power's contribution to the world's energy supplies is significant and growing, but still rather small. See Figure 9.3. Mid-1980s statistics assembled by the International Atomic Energy Agency (IAEA) revealed there were almost 400 nuclear reactors connected to the electricity supply networks in 26 different countries. These nuclear power stations possessed a combined generating capacity of 248,000 megawatts and produced about 15 percent of the world's electricity.

However, electricity is only part of the world's energy mix. Approximately 35 percent of the energy countries consume on an annual basis is committed to generating electricity. The rest is devoted to the production of heat and to the transportation of goods and people. Nuclear power therefore accounts for only about 5 percent of the total energy used throughout the world. Further, because of the heat lost in power generation, it only accounts for 2-3 percent of the energy actually delivered to end users. Some nations, however, are much more dependent on nuclear power than others as shown in Figure 9.4.

Prior to the Chernobyl accident, the European area of the Soviet Union relied on the atom for approximately 20 percent of its electricity. Twenty-three graphite-moderated reactors supplied roughly half of nuclear energy's overall 11 percent contribution to Soviet power generation. The remaining nuclear contribution came from pressurized, light water reactors similar in design to most western plants. At present, the Soviets seem to be intent on relying more heavily on this type of design into the 21st century. By that time, the Soviets are hopeful nuclear energy will satisfy over 30 percent of their electrical needs.

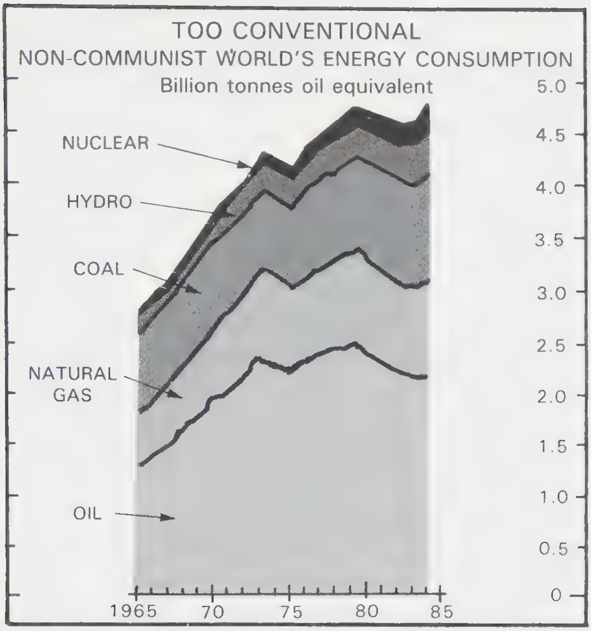


Figure 9.3 Chart showing percentage distribution of nuclear power to world's energy consumption. (British Petroleum)

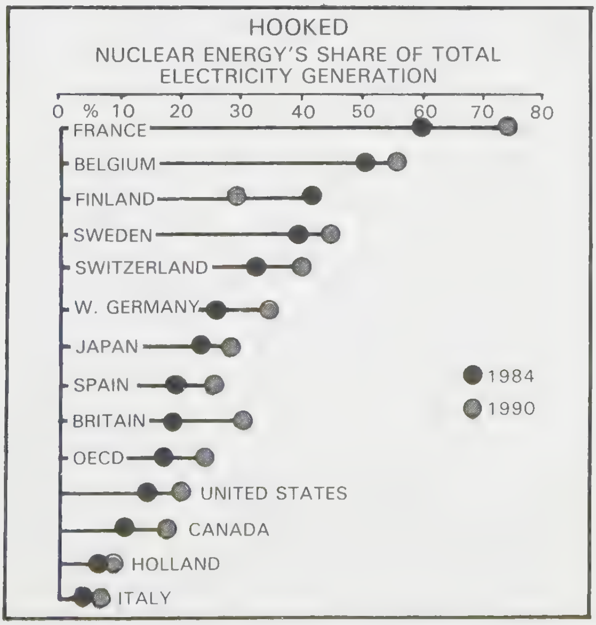


Figure 9.4 Chart showing the extent to which individual nations are dependent on nuclear energy for electricity. (Nuclear Energy Agency)

Two of Europe's most avid nuclear enthusiasts are Belgium and France. The latter operates the most extensive nuclear energy program on the western European continent. The French generate about 70 percent of their electricity using over 40 active nuclear reactors while another 15 or so are presently under construction. The primary response by the French government to the Chernobyl incident has been a campaign to convince worried neighboring countries its own reactors are safe. Belgium generates about 60 percent of its electricity from 7 nuclear reactors. Plans to order new reactor construction might be delayed because of the Soviet accident. Other European countries presently considering abandonment of their plans for nuclear expansion include Sweden, West Germany, Finland, Italy, The Netherlands, and Spain.

In the United States, the Edison Electric Institute (EEI) released a report concluding major reforms are needed in the electric utility industry and in federal law in order for nuclear power to become a significant energy option in the future. At present, the United States uses nuclear power plants to generate approximately 15 percent of its electricity. Executives of United States nuclear utilities recognize the need for the industry as a whole to improve its performance if they wish to regain public confidence in nuclear power.

EEI officials believe that public perceptions will only be improved if the entire industry can:

1. Reduce constant-dollar (inflation adjusted) construction costs of nuclear units.
2. Make reactor units more predictable.
3. Shorten nuclear construction periods to the durations now achieved overseas and formerly in the United States (France builds a plant in about 7 years while the United States take as many as 12 to 14 years.
4. Improve construction quality to eliminate the risks that force nuclear units to stand finished but inoperable.

The Utility Operation Services Inc. recently confirmed many American nuclear power plants do not measure up to the performance levels achieved in foreign countries. In terms of safety and reliability of operation, nuclear plants in the United States ranked fairly low in performance. Refer to Figure 9.5. This situation is totally unsatisfactory and can not be allowed to continue. Now, more than ever, the nuclear utilities seem to be committed to improving the performance capabilities of their plants. The establishment of the Institute for Nuclear Power Operations illustrated a dedication to safety and operating quality and the desire to prevent another incident like Three Mile Island.

The safety of nuclear power plants will remain a major issue shaping the long-term future of the technology. The years of nuclear energy use continue to add up. If one counts all the commercial nuclear power plants operating around the world and the experience of power reactors propelling submarines and surface ships in the United States Navy, more than 6000 reactor years of operation have been accumulated to date. It should no longer be considered an experimental technology. Its health and safety impact is equal to or even less than other energy sources we seem to accept more casually. This is not

WHO IS TOPS IN NUCLEAR PERFORMANCE?		
Country	**Total No. of Units Studied**	**% In Upper Half of List**
Canada	10	100
Taiwan	4	100
Belgium	3	100
Finland	2	100
France	24	75
Germany	10	70
Japan	19	63
Sweden	8	63
Spain	2	50
South Korea	2	50
US	68	22
Britain	4	0

Figure 9.5 Chart summarizing performance ratings of nuclear reactors around the world. (Utility Operations Service, Inc.)

meant to imply the public should be convinced there are no risks from nuclear power. Nuclear power is a complex and technologically demanding undertaking. Regardless of where it is adopted, it requires a community of thoroughly trained engineers, scientists, and technicians to design, operate, manage, and regulate every element of the nuclear fuel cycle. It is only under these restrictive circumstances that nuclear energy should be considered a technology mankind can control.

NUCLEAR REACTOR DESIGNS

Reactor Core

The primary components of a nuclear reactor are the radioactive fuel, a moderating material of some sort, control rods, and a method whereby heat can be removed from the reactor to be directed toward the steam turbine. Study Figure 9.6.

The nuclear fuel is present in the form of UO_2 (uranium dioxide) pellets which are cylindrical in shape measuring about an inch in diameter and an inch and half long.

The moderator is essential to slow down the neutrons produced by the fission reaction. The moderator should contain light atoms that do not easily absorb the neutrons but allow the chain reaction to continue. Water, beryllium, and graphite are effective moderators. Water is the least expensive and often the most convenient moderator. It is a common procedure to use the same water to carry heat away from the atomic core to the steam generator.

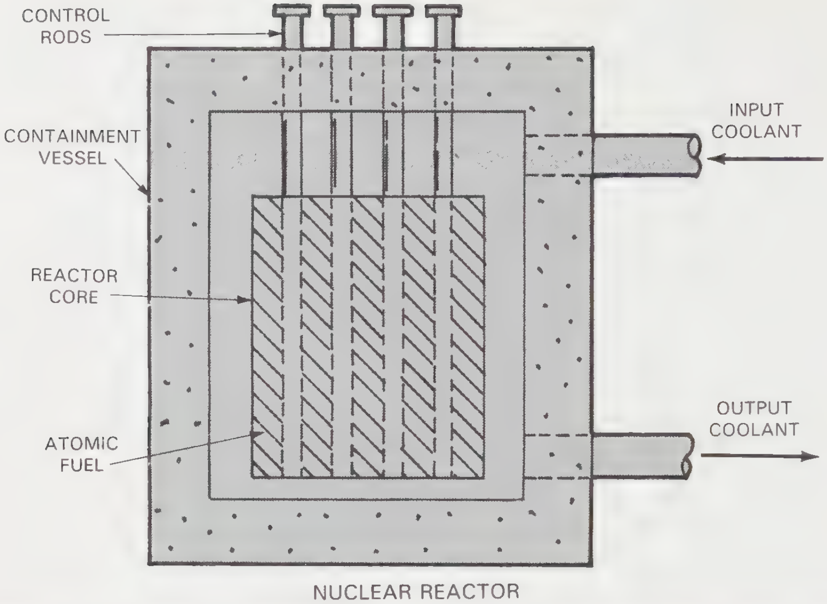


Figure 9.6 Illustration of the primary elements found inside a nuclear reactor core.

Control rods are long cylindrical rods composed of a material such as boron, or boron carbide and aluminum. Unlike the moderating materials, these elements are supposed to absorb neutrons. When the control rods are inserted into the atomic core, they capture neutrons and effectively slow down the chain reaction. They are a critical safety mechanism since they can be fully inserted into the core to halt the chain reaction in case of any type of an accident.

Heat is removed from the core by a circulating coolant. This coolant may be either a gas or a liquid. It is pumped through the core where it makes contact with the hot fuel rods. Ultimately, it carries heat away from the core to be used to drive the turbine.

Nuclear Fuel

Uranium is mined and converted to U_3O_8 (called "yellow cake" in the industry) through a milling process that entails crushing, screening, washing, and gravitational separation. "Yellow cake" contains .71% U-235 and 99.3% U-238. The former is the isotope directly fissionable by slow neutrons. U-238 is not fissionable but can be converted to plutonium which is another fissionable fueling agent. Most nuclear reactors can not run on natural uranium because the neutron losses are too high. For this reason, the U-235 isotope is enriched to about 3% using a complicated gaseous diffusion process.

Following enrichment, pellets of UO_2 are inserted into tubes lined with a thin-wall of Zirconium alloy cladding (a strong, ductile metallic element). The resultant fuel rods are assembled into bundles of a few hundred. Some rods are purposely left empty to allow for control rod insertion. These assemblies are next positioned inside the nuclear reactor where they serve a useful life of three to four years. Spent rods may either be sent to a reprocessing plant or placed in water filled storage ponds at the reactor site. In nuclear physics terminology, the length of time a material remains radioactive is expressed in terms of its half-life. Plutonium (Pu-239) is an isotope found in used nuclear reactor fuel rods. It has a half-life of 24,000 years! When you consider this single fact, the concept of nuclear waste "storage" becomes somewhat elusive. Figure 9.7 presents a flow diagram of the nuclear fuel cycle as it presently exists in nations who operate nuclear reactors.

There are several blueprints to construct a nuclear reactor. Generally speaking, the world's commercial power reactors are one of four principal designs:

1. Pressurized Water Reactors (PWR).
2. Boiling Water Reactors (BWR).
3. Heavy Water Reactors (HWR).
4. Gas Cooled Reactors (GCR).

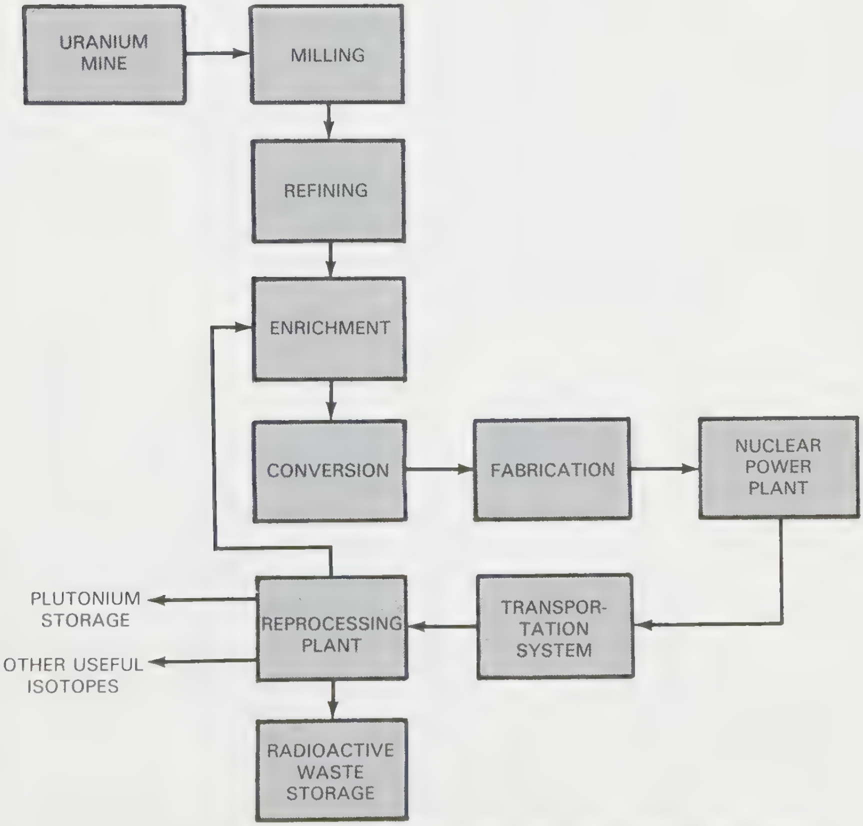

URANIUM MINE
MILLING
REFINING
ENRICHMENT
CONVERSION
FABRICATION
NUCLEAR POWER PLANT
TRANSPOR-TATION SYSTEM
REPROCESSING PLANT
PLUTONIUM STORAGE
OTHER USEFUL ISOTOPES
RADIOACTIVE WASTE STORAGE

Figure 9.7 Flow diagram depicting the typical nuclear fuel cycle.

Most reactors currently operating in the United States fall into the first two categories, collectively referred to as light water reactors (LWR). All of them derive energy from the fission of uranium-235 atoms in uranium fuel using neutrons that travel at speeds comparable to those of air molecules (generally called slow or thermal neutrons). The fission process produces further neutrons which are emitted with very high energies (read high velocities). These particles must be slowed down by atomic collisions in a moderator containing water, heavy water, or graphite. Heavy water consists of deuterium oxide (D_2O) which is an isotopic form of water present in natural water as approximately 1 part in 6500.

In heavy water reactors (HWR) or graphite-moderated gas reactors, the chain reaction can be sustained by using natural uranium as the fuel (.71% U-235 and 99.3% U-238). Neutron capture in the moderator of light water reactors (PWR, BWR) prevents the establishment of the chain reaction unless the fissile isotope U-235 is increased above its natural level. As mentioned earlier, enrichment to 3% is common.

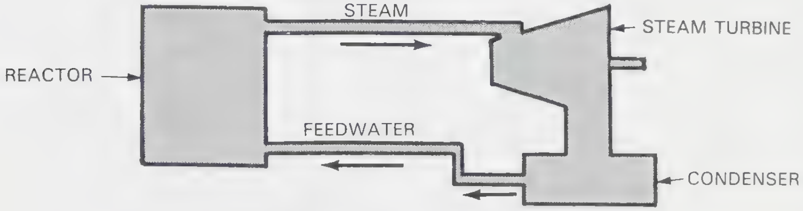
Energy in the nuclear reactor core is released partly in the form of kinetic energy created during the splitting of the uranium atom. Radiation is also emitted by the decay of unstable elements produced in the fission process and through neutron capture. These appear as heat which is extracted from the core using either light or heavy pressurized water (PWR, HWR), steam (BWR) or a coolant gas (GCR). In the latter type, carbon dioxide is usually employed but helium is sometimes used in reactors designed to operate at higher temperatures. The coolant, in turn, is used to produce steam to drive a turbine in the same way as in a fossil fuel burning station. The BWR uses its steam directly without an intermediate heat exchanger. Figure 9.8 provides schematic illustrations of these reactor designs.

Breeder Reactors

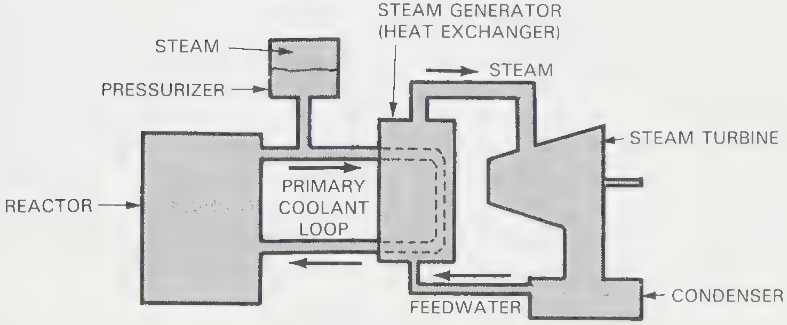
Unlike other reactor designs which burn up or exhaust their supply of fuel, breeder reactors produce more fissile material than they consume. See Figure 9.9. The major scheme being investigated is known as the liquid metal fast breeder reactor (LMFBR) which is designed to use liquid sodium as its circulating coolant.

The breeder reactor core contains fissionable uranium-235 surrounded by non-fissionable, but fertile, uranium-238. During operation, the U-238 is bombarded by high-energy or "fast" neutrons which ultimately leads to the production of plutonium-239 as a by-product. Since U-238 is a finite resource, it will eventually be used up. Most "burner" reactors use U-235 which is even rarer. U-238 is 140 times more plentiful than its U-235 counterpart. The plutonium produced can be used to fuel other reactors. This fact increases the potential life of nuclear reactors as a power source from less than 100 years to perhaps thousands of years.

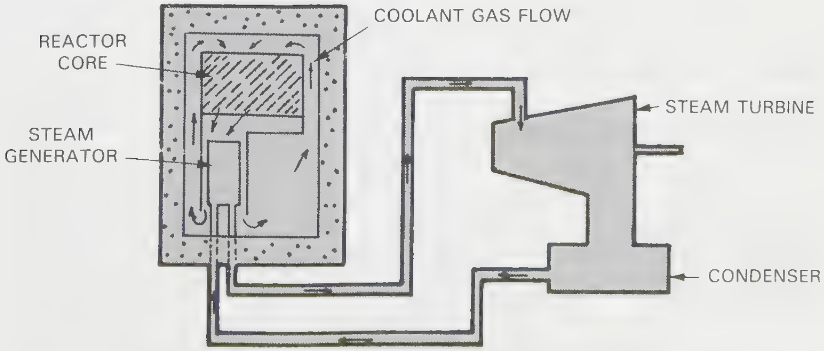
Ostensibly, the main advantage of breeder reactors is the small uranium supply needed to run them. This signifies a measure of energy independence for those nations not possessing large amounts of natural resources. The United States has spent huge sums of money on its breeder program but has yet to bring this type of reactor into operation. The primary obstacles seem to reflect a healthy dose of uncertainty regarding the establishment of large-scale fuel reprocessing plants in this country and the need to provide heavy security for military grade plutonium.


STEAM
STEAM TURBINE
REACTOR
FEEDWATER
CONDENSER

BOILING WATER REACTOR (BWR)

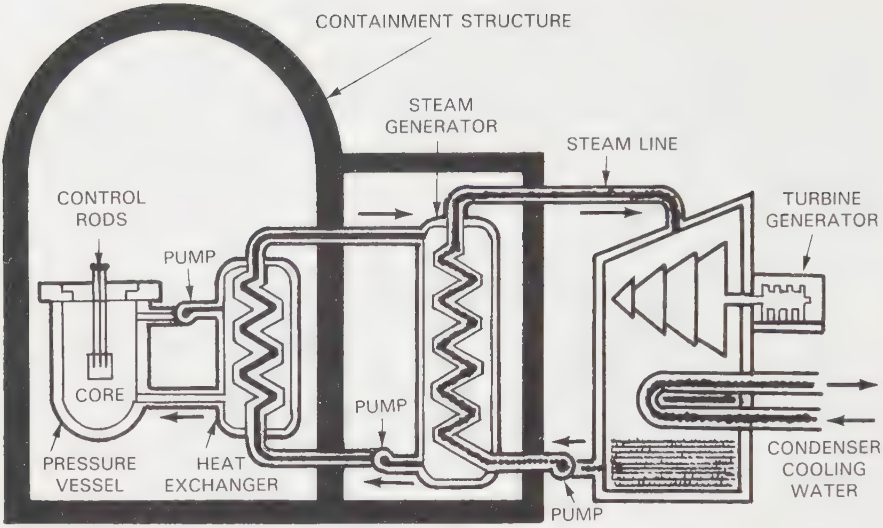

STEAM GENERATOR
(HEAT EXCHANGER)
STEAM
PRESSURIZER
STEAM
STEAM TURBINE
REACTOR
PRIMARY
COOLANT
LOOP
CONDENSER
FEEDWATER

PRESSURIZED WATER REACTOR (PWR)


COOLANT GAS FLOW
REACTOR
CORE
STEAM TURBINE
STEAM
GENERATOR
CONDENSER

HIGH TEMPERATURE GAS-COOLED REACTOR (HTGR)

Figure 9.8 Schematic illustrations of various nuclear reactor designs.



A breeder reactor produces more fissile material than it consumes. The liquid metal fast breeder reactor, shown, begins operation with a core of fissionable uranium-235 surrounded by a ''blanket'' of nonfissionable uranium-238. During operation, the uranium-238 is bombarded by high-velocity neutrons from the uranium-235 fission and is transmuted to plutonium-239, thus ''breeding'' plutonium from uranium. (The core can also be made of plutonium-239; the neutrons from the fission bombard the uranium-238 in the same way and create even more plutonium.) The plutonium can be extracted through chemical processing and converted into new fuel. The breeder reactor also produces electricity: the energy from the reaction heats liquid sodium, which in turn heats water to steam. The steam drives a turbine, which generates electricity.

Figure 9.9 Schematic illustration of a nuclear breeder reactor.

Breeder reactors are receiving more rigorous activity in France, Japan, Great Britain, and Germany. The Soviet Union has also made progress toward the development of this technology. The relatively low prices for uranium and improvements to decrease the cost of fuel enrichment are projected to continue for the next decade. Extensive introduction and implementation of breeder reactors into the world's energy mix will most likely be delayed into the early years of the next century.

NON-NUCLEAR ENERGY OPTIONS

By the middle of the 21st century, the incident at Chernobyl might be viewed as either the beginning of the end of nuclear energy or as an unfortunate glitch in its adolescence. The popular perception may very well be based on politics rather than technological advancement. A significant number of persons around the world seem convinced the danger associated with nuclear power is too great at any price. This attitude may eventually stimulate further dependence on a variety of non-nuclear options. Several of the choices that might gain attention are discussed in the following segments of this chapter.

CONVENTIONAL SOURCES (Non-renewable)

Fossil fuel power stations generate electricity by burning fuel to boil water. Steam in turn drives turbines. The conversion efficiency of this method of power generation is commonly estimated at about 35 percent. In other words, only 35 percent of the energy contained in the fuel is output as electricity. Current energy technologists are at work trying to enhance this efficiency rating through the use of fuel cells.

At its best performance level, a fuel cell can convert up to 85 percent of the energy released by the oxidation of hydrogen gas into electric current and usable heat. Fuel cells work by stripping hydrogen, methane, or methanol of its electrons at one electrode and giving them back, together with oxygen, at another electrode. The net result is oxidation. This is essentially the same process as when the fuel is burned. However, the electrons travelling between the electrodes can be used as electric current. Compared with turbines, fuel cells are a lot quieter, cooler, and more compact.

The primary drawback of fuel cells is still cost. At present, a fuel cell can not compete with a turbine generator even if it runs on natural gas. The picture is even dimmer if we consider using methanol or hydrogen, both of which are much more expensive to produce. The electricity industry has its eye on the future developments in this area. Prototype fuel cells have been built and tested in the United States and Japan.

The case of transportation clearly illustrates the difficulties of moving toward a post-petroleum economy. Current transportation needs around the world are presently being met almost entirely by oil. There is no other energy source available today that can meet the demands for an easily portable and storable fuel. Providing energy for transportation poses a huge challenge for both nuclear power and solar sources.

Oil remains the world's most popular fuel. But it does not seem prudent to burn it in power stations. The first reason is it truly seems indispensable as the fuel for moving things around. Almost half of the oil used today powers transport of one form or another. Second, burning more oil would very soon deliver consumers back into the throes of OPEC's erratic decisions. A third reason is oil is a finite resource. Most experts project the world's proven oil reserves will be depleted in less than four decades. Interestingly, if this fuel had been used to produce the amount of electricity the world's nuclear power stations generated in one year, international consumption would have been about 10 percent higher.

Natural gas holds the number two position as the fuel of choice around the globe. The composition of raw natural gas varies widely but it consists mainly of methane (CH_4). Figure 9.10 presents a list of the heavier hydrocarbon components known collectively as natural gas liquids that must be separated out before the natural gas can be marketed.

Natural gas is relatively very clean and easy to burn in simple equipment. It is the basic fuel for much of the petrochemical industry. Its development has lagged behind that of petroleum because of the difficulty of transporting

COMPOSITION OF RAW NATURAL GAS

Methane—the principal component (between 75% and 100%)—used as an industrial and domestic fuel.
Ethane—used chiefly as a feedstock for petrochemical plants manufacturing ethylene; sometimes used directly as a fuel.
Propane and Butane—liquefied petroleum gases or ‘LPGs’—wide-ranging commercial uses as residential and industrial fuels and as petrochemical feedstocks.
Pentane, and even heavier hydrocarbons—‘condensate’—can be blended with other gasoline fractions to make ‘natural gasoline’; also used as petrochemical feedstock.
Nitrogen, **carbon dioxide**, and other inert constituents.

Figure 9.10 Table listing components of raw natural gas.

it in large quantities. Land transport of natural gas requires large-diameter pipelines with customers residing at the receiving end. Sea transport of natural gas is quite expensive. It is shipped in what are called LNG tankers. LNG is an abbreviation for the liquification of natural gas which must occur if it is to be transported across the ocean.

Prior to the 1940s, natural gas was rarely sought, often deplored when discovered, and many times flared on-site when it was found to reach precious oil reserves. Over the years, large amounts of natural gas were reportedly burned in the Middle Eastern oil fields. Present techniques prescribe reinjection of the associated gas back into the oil fields to maintain underground pressure. Gas pipelines cover the United States, Canada, Western Europe, and the Soviet Union. Essentially, the pace of development of international natural gas pipeline projects has been constant over the past two decades. One project that has received its fair share of media attention is the lengthy line running from Alaska to the United States west coast and mid-western region. See Figure 9.11. Estimates regarding the potential life of natural gas vary widely from 10 years to over 100 years.

In the years following the second World War, many countries tried to move away from their dependence on coal. In the eyes of many persons, coal is the fuel of the past. It is, at best, considered a stopgap measure used until more “high-tech” options become available. Approximately 40 percent of the world’s electricity is being produced by coal-fired generating plants.

Coal is dirty and dangerous to mine, expensive to transport, and harmful to the atmosphere. A large coal-fired power station produces staggering amounts of ash as a waste product. It also pumps out carbon dioxide which contributes to global warming, commonly known as the “greenhouse effect.” Coal plants also emit sulfur dioxide and nitrogen oxides which reappear as acid rain. At today’s consumption rates, known coal reserves could easily last for 200-300 years.

If we decide to burn more coal to generate electricity (instead of nuclear fuels), the world will be forced to accept more pollution or pay higher prices to clean up the coal. Optimists report fluidized-bed combustion technology

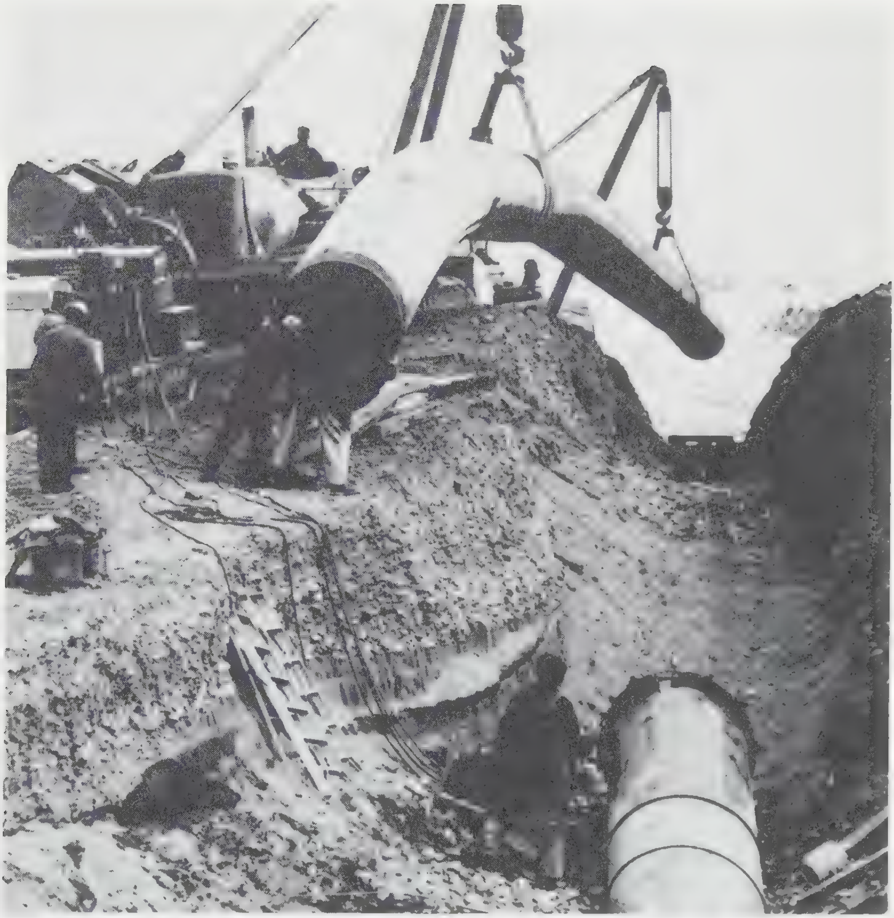


Figure 9.11 A section of pipe for the trans Alaska pipeline bent to conform to the contour of a pipe ditch north of Valdez and lowered into the ditch by sideboom tractors for welding to the pipe section lying at the lower right. About half of the 800-mile long pipeline was buried in ditches 8 to 16 feet deep. (National Archives)

for use in the coal industry should be out of its experimental phase by the mid-1990s yielding fewer pollutants and a higher power output.

The United States Department of Energy reports we already have the ability to build a coal combustor which removes the sulfur inside the boiler while the coal is still burning. We also have the know-how to take finely ground, deeply cleaned coal mixed with water and make it behave just like oil. Coal enthusiasts are also presently looking at ways to apply genetic engineering to the technology of coal. They project the use of micro-organisms to eat away pollutants or to even convert the coal into synthetic liquid fuels. The present cost of producing a barrel of synthetic oil from coal is still prohibitive but may become more competitive as oil supplies grow lean.

ALTERNATIVE SOURCES (Renewable)

Renewable sources of energy, by definition, can not run out. Some energy writers say they are "eternal." Generally speaking, they do not blow up, melt down, or pollute the environment. The fears associated with clandestine terrorist activities are not typically aligned with the energy sources found in this category. After the first oil crunch of the early 1970s, optimistic forecasters claimed alternative energy sources could eventually meet all of the world's energy needs. Due to the fact all renewables have at least two inherent shortcomings, that optimism has faded somewhat over the past few years.

Renewable sources of energy are diffuse (spread thin) and intermittent. One example of the diffuseness feature is that a 1000-megawatt solar farm might occupy about 5000 acres of land, while a nuclear power station with the same generating capacity only requires around 150 acres. Since renewable energy is intermittent, it is also unreliable. Although the wind often blows strongest when most power is needed (late afternoon and evening), it can not be counted on to do so each day. Likewise, the sun may not always shine when you expect it to—consider the last time you were forced to cancel an outing! For these reasons, any renewable supply must be attached to an efficient means of storing energy for the lean time. Storage systems are becoming more efficient but commonly waste up to 20 percent of the accumulated energy. Despite these limitations, renewable energy is making a visible contribution to electricity grids in various parts of the world.

Renewable energy industries produce energy using resources such as sunlight, wind, water current, and organic waste. Each is continually replenished by eternal forces in nature. Contemporary renewable energy technologies include solar thermal energy, biomass energy, geothermal energy, solar photovoltaics, wind energy, small hydroelectric energy and ocean energy. The first three on the list generate heat energy while the remaining techniques directly generate electric power. The United States has led in the development and advanced application of renewable energy technologies and resources. Other nations regularly enter into this aspect of the world's energy arena.

Geothermal Energy

This form of energy is not strictly renewable or eternal from the standpoint the earth's rocks will "eventually" cool down. Residents of Italy will also argue that, contrary to some publications, it is not a "new" form of energy. The Italians have been running a power station fueled by hydrothermal power (steam plus hot water) intermittently since 1913. The potential of this form of energy is limited by the planet's relatively small number of high-quality reserves of sub-surface steam and hot water. For those countries where active geysers have been found, geothermal power generation is quite effective. New Zealand attributes 11 percent of its total energy consumption to this resource. At the Geysers in Northern California, more than 20 separate power plants have been installed.

There is a great deal of heat trapped inside the earth just waiting to be vented. But larger scale uses of geothermal power are still at least a decade or more in the future. Central America, parts of Southeast Asia, and the western United States have the greatest potential for major reliance on geothermal energy. Promising sites also exist in parts of southern Europe and East Africa. Taking full advantage of this resource will necessitate new technologies to tap into deeper geothermal reservoirs and make use of lower temperature geothermal waters.

Wind

Experts in the field of alternative energy feel wind energy is the most auspicious (favorable) of the renewables. Windmills mechanically turn turbines without an intermediate stage of heating water. In the early 1980s, more than 8000 wind machines were installed in California. One of the largest wind farms is presently found in the rolling, windswept hills of the Altamont Pass, east of San Francisco. Note Figure 9.12. Wind farms are clusters of machines, generally located in mountain passes, connected to utility lines.

Figure 9.12 Since the early 1980s, over 5,600 wind turbines have been installed in the Altamont Pass outside Livermore, California. This collection of wind turbines represents the largest power plant fueled by wind in the world. The wind turbines are strikingly different in appearance representing nearly 20 manufacturers. Each distinct cluster of machines is a privately owned windfarm with its own collection and transmission system for delivering electrical power to Pacific Gas & Electric. These wind turbines incorporate recent engineering advancements in materials, electronics, and aerodynamics. (Michael Dafferner)

Attempts to reap economies of scale by building larger windmills capable of generating more than one megawatt of power have been suppressed by technical problems. Capital costs have remained prohibitive. More reliable and less expensive wind machines are being designed and built. This may stimulate the adoption of this technology in parts of the world where wind conditions are less than ideal.

Biomass

The most common renewable source of energy is organic plant matter. Many developing countries depend on wood and agricultural waste for energy. Almost half of India's and nearly 90 percent of some small countries in Africa total energy consumption is provided by wood. India attains another tenth of its energy from animal dung and crop waste. The highly precarious nature of these resources must not be overlooked.

In many areas of the developing world, trees are being used up faster than they are being replaced. Also, when dung is burned for energy, farmers deprive their fields of essential nutrients. As a result, they reduce the amount of crops grown and fed to cattle to produce more waste matter. One solution may be found in biogas. Digesters can use the dung to make methane gas and also yield a residue that is good fertilizer. China is already making use of several thousand digesters across its expansive land mass.

Plants may have a modest future in replacing the oil used as a fuel for vehicular transportation. Brazil presently commands an impressive program of ethanol production from its sugar cane crops. In other parts of the globe, vehicles are running experimentally on coconut oil in the Philippines and gopherweed in Arizona. In Florida, sewage-fed water hyacinths are being converted into gas. The Japanese are experimenting with microorganisms that eat rice waste to produce hydrogen which could ideally be used in conjunction with fuel cells.

The Ocean

Three methods for extracting energy from the sea have been reviewed seriously: wave power, ocean thermal energy conversion, and tidal power. The first aims to harness the motion of the waves using a variety of devices. The second seeks to exploit the temperature differences between the warm surface layer and the colder deep waters of the world's oceans. Both could generate sizeable amounts of electricity, but neither one has yet been demonstrated much beyond the experimental stage.

The third method is known as tidal power. It is similar to hydroelectric power in the sense it is severely restricted by geography. It requires long, tapering bays that drive the tide into a large bore as it moves along the channel. The incoming tide can then be trapped behind a barrier of some sort and ultimately used to drive turbines on its way out again. There are not very many sites that have these specific geographic features around the world. Two suitable locations are found at the Bay of Fundy in Canada and the Severn Estuary in Great Britain.

Photovoltaic Cells

Semi-conductors have the unique property of being able to turn sunlight directly into electric current. This application is surfacing in a variety of items such as solar-powered calculators, refrigerators, and satellites. According to some energy forecasters, solar cells installed on rooftops may allow for a much greater decentralization of electricity than other technologies. Photovoltaics, however, are still too expensive for large scale power generation. Developers have not yet been able to make cells cheaper without sacrificing conversion efficiency.

Thermal Solar Power

Solar thermal power technologies and solar ponds are projected to have competitive generating costs by the end of the century. The capital cost for expensive items like polished mirrors to track the path of the sun is presently exorbitant.

One of the most ambitious projects in this aspect of energy resource development was recently completed by Southern California Edison (SCE), one of the world's leading innovators of alternative energy methods. With the support of a multi-million dollar grant from the United States Department of Energy, SCE constructed the country's first commercial scale solar electric facility in the Mojave Desert. Known officially as Solar One, it is currently the largest central receiver solar plant in the world. See Figure 9.13. A 300-foot

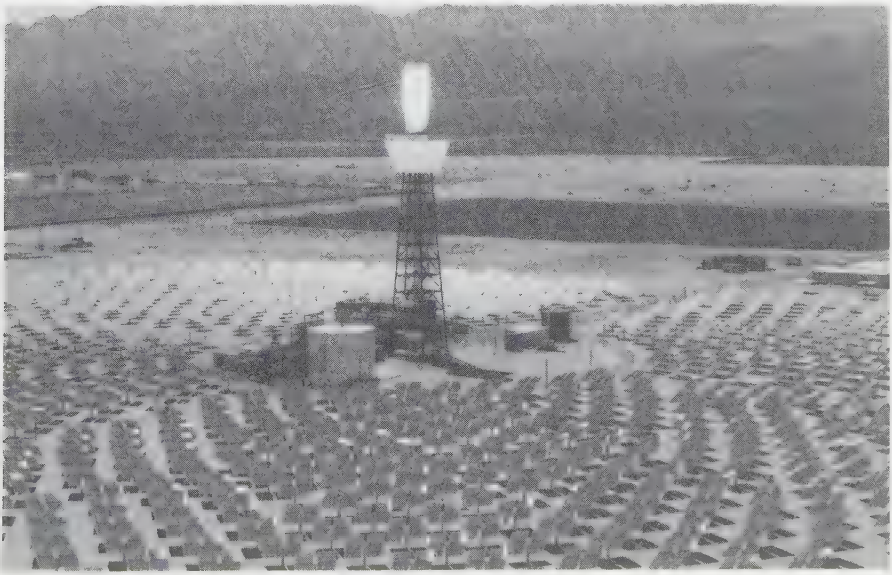


Figure 9.13 Solar One, a 300-foot tower is encircled by a huge array of mirrors in California's Mojave Desert. It is the United States' first commercial-scale solar-electric facility. At the time of this writing, Solar One is the largest central-receiver solar plant in the world. (Southern California Edison Company)

tower, fondly referred to as the Tower of Power, is encircled by more than 1800 mirrors. In the Mojave Desert, direct sunlight often produces temperatures of 160 degrees at the earth's surface. If the same sunlight is concentrated across a parabolic surface, temperatures six times higher can be realized. Solar One's parabolic mirrors reflect sunlight onto a sophisticated boiler mounted on top of the tower. The boiler houses about a mile of looped, superalloy water pipe connected to an intricate plumbing system. The result is a healthy release of steam to drive a turbine generator producing about 10 megawatts of electricity at maximum output.

Solar One produces power only when the sun shines. A sharp-edged cloud large enough to block the sun for just five minutes will automatically trip the turbine. System restart can take more than an hour. Future power towers will most likely incorporate more adequate heat retention properties to avoid such erratic and costly shutdowns. As the technologies associated with this alternative energy source are honed and improved, capital costs per kilowatt hour will gradually become more acceptable.

It is unlikely the solar technologies described here or the other technologies mentioned will ever totally replace the world's conventional energy options. The most important point to recognize is they most definitely belong in our international energy mix as we continue with our quest toward the creation of a sustainable society. We must maintain our momentum toward the further development and advancement of all potential energy resources in order to make the imminent transition to an oil-independent civilization with the least amount of trauma.

ENERGY CONSERVATION

Two words linked with the term energy are "efficiency" and "conservation." Most of us would have very little difficulty recalling an incident or casual conversation when these terms were used. If you refer back to the DATELINE topic presented at the start of this chapter, the notion that automakers around the world are concerned about making their vehicles more energy efficient seems wonderful. In a similar vein, multinational corporations have launched huge fact-gathering projects to promote energy conservation efforts among their employees.

It is not easy to deny the prevalence of these issues. However, consumers still have a considerable distance ahead before their behavioral modifications seem permanent. You have learned that with the exception of a small portion of the electromagnetic spectrum, energy is invisible. In many ways, energy might be described as also being psychologically invisible when persons are unable (or perhaps unwilling) to see the connection between the actions they take and the resulting energy they use. Unfortunately, this seems pointedly true when you consider this country's residential electric bills which are distributed to consumers on a monthly basis. Most of us purchase lighting, heat water, use appliances, heat space, and air conditioning without the vaguest idea of how much each item costs. Consider the following examples.

1. When was the last time you returned to an unoccupied room to turn off the light?
    a. Yesterday.
    b. Last Week.
    c. Last Year.
    d. Never.
2. When was the last time you checked the energy efficiency rating of the water heater you depend on for hot showers?
    a. Yesterday.
    b. Last Week.
    c. Last Year.
    d. Never.

If you answered (a) or (b) to question one and (c) or (d) to question number two, your responses correspond with a large majority of today's householders. Motivated by high monthly bills and gasoline prices, people often try to save energy. However, they are often disappointed because they take ineffective actions and overlook potentially more effective measures. As a result, some actually give up on conservation altogether. Energy's invisibility also means when people do manage to implement effective energy conservation measures, they never know exactly how much they have saved. This situation often prevents good (read permanent) conservation practices from earning the reputation they deserve.

We no longer live in a society where energy conservation is a voluntary option and energy illiteracy is OK. Regardless of all the time, money, governmental directives or scientific diligence devoted to improving the international energy system, the human dimension remains paramount. Opportunities to save energy are many and impressive but their long-term effectiveness will depend on people, not technology. Energy conservation must not be perceived to be synonymous with sacrifice. Persons are not too motivated to conserve energy if they feel like they must "give something up" in the bargain. Improving energy efficiency and using energy resources conservatively should be viewed as behaviors to provide a greater measure of control over mankind's destiny.

If developing countries are to be able to ultimately reach their industrial development objectives, a significant increase in energy consumption will be required. Energy conservation policies at the outset will certainly play an important role in assisting these nations to meet their expanding energy needs. If industrialized nations expect to sustain the quality of living to which they have become accustomed to over the past several decades, energy conservation attitudes are imperative. Energy conservation is not simply a technical matter—it is a challenge to be met by the humans who actually produce and consume energy. All of us should be motivated to conserve it too!

SUMMARY

The topic of international energy politics is replete (filled) with excitement and confusion. Several key actors appear to be charting an energy policy course which will guarantee their influential positions as both producers and consumers.

Generally speaking, it appears the world's industrialized nations will continue to consume a large amount of energy produced from petroleum and other conventional resources. Developing nations have indicated their interests in expanding a variety of alternative energy sources and some seem open to the construction of nuclear reactors on their soils.

The final segments of this chapter barely touched on the critical issues of energy conservation and efficiency. Persons around the world must immediately begin to shift their energy attitudes away from ignorant consumption behaviors toward intelligent conservation strategies. Many citizens believe another energy crisis is just around the corner. Others think it is foolish to think that way—we have plenty of energy, Enjoy it! You must decide for yourself which group you fit into. In either case, keep abreast of the ever-changing dynamics of contemporary energy politics and make a concerted effort to take note of your energy sources. These two private exercises will help all of us feel a bit more secure about the availability of energy resources fifteen or twenty years down the road.

DISCUSSION QUESTIONS

1. Describe with some detail at least two recent incidences when the energy source you "expected" to be available was for one reason or another absent. How did you cope with the situation?
2. What was the purpose of the Carter administration's National Energy Plan? Discuss its effectiveness.
3. OPEC and IEA are two examples of international governmental organizations. How do their current activities complement each other? Describe the functions of each group in the arena of global energy politics.
4. Sketch, identify and describe the most important operational elements of a nuclear reactor core. How do conventional nuclear "burners" differ from breeder reactors?
5. Explain some of the advantages and disadvantages to using coal as the primary energy source of the future?
6. Discuss two major drawbacks that are characteristic of all "renewable" energy sources. What strategies might be used to overcome them?

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Chapter 10

ENVIRONMENTAL ISSUES

DATELINE

Coyote Valley, California

The bay checkerspot butterfly is proposed for inclusion on the federal endangered species list. The plight of this colorful white, orange, and brown butterfly eventually became the focal point of a classic struggle between environmentalists and industry. Found only in Santa Clara and San Mateo counties near the San Fransisco Bay, the major colony of the tiny bay checkerspot lives at the southern end of the Coyote Valley. The butterfly's adult life lasts only 11 days and produces one generation each year starting in late February. See Figure 10.1.

Key officials in this particular controversy involved the U.S. Fish and Wildlife Service and Waste Management Inc. The latter is a large sanitation company that had gained approval to build and operate a 300-acre landfill in this area. The landfill has a projected lifespan of 55 years during which time Waste Management has also agreed to protect the imperiled butterfly species. Although landfill operations will disturb the butterfly's habitat, 250 acres will be set aside, fenced and never disturbed to insure its preservation. In actuality, the creature's future may be brighter than ever before . . . .

INTRODUCTION

In all likelihood, a majority of the discussions you have heard relative to the impact of technology on the environment have had a negative overtone. In fact, the evolution of the phrase "environmental impact" as a modifier for such words as assessment, report, and statement is directly related to this mode of discussion and/or debate. Protection of the natural environment has become a key issue in almost all dialogue surrounding the international advancement of technology.

Although the issue of environmental protection has a relatively short history when compared with the chronology of technological development, it has

Figure 10.1 The U.S. Fish and Wildlife Service has declared the Bay Checkerspot Butterfly (Euphdrayas editha bayemsis) to be a candidate for the rare and endangered species list. When a new landfill site was identified as a habitat for this butterfly, Waste Management of California, Inc. developed a program to protect it. A controlled grazing program within a 250 acre fenced area will protect the plant community on which the butterfly depends for food, protection, and reproduction. (Waste Management, Inc.)

received a great deal of media attention throughout its existence. Participation in these often dramatic cover stories has not been limited to the scientific, technological, and political arenas. The general public has continually maintained an active voice at the "grass roots" level which has stimulated much of the regulatory legislation currently in effect.

Widespread concern about the long-term effects of technology and its many by-products on the natural system of the biosphere began during the mid-1960s. The United Nations Conference on the Human Environment held in Stockholm in 1972 placed a series of environmental issues on the official agendas of national governments around the world. In other words, the environment is still a fairly new item on the prospectus of international affairs.

An attempt to generate a comprehensive list of the critical areas of environmental concern would be challenging. It would also be directly influenced by the degree of technical and/or scientific background possessed by the respondents surveyed. Without question, some of the more serious matters that dictate a sense of urgency include: air quality, climatic stability, moist tropical forests, arable lands, water potability, and management of hazardous materials. At mid-twentieth century, none of these topics was a political discussion topic let alone an issue of international magnitude.

The intent of this chapter is to familiarize you with several environmental conditions that can no longer be overlooked or ignored if future generations are to be assured of a natural environment hospitable to quality of living. The extent to which these conditions are either a direct or indirect result of the advancement of technology in society will most likely remain a debatable issue.

1. What does it mean to be labeled as an "environmentalist" in today's social circles?
2. Has there been any significant progress made in international environmental cooperation?
3. What effect has governmental intervention had on the quality of air we breathe in this country?
4. What strategies are currently being proposed and/or implemented to deter the degradation of the world's remaining tropical forests?
5. How can the dangerous waste materials generated by advanced technological societies be managed most effectively?

KEY CONCEPTS

As you review this chapter, you should develop an understanding of these concepts:

Pollutant Standards Index
Greenhouse Effect
Environmental Impact Analysis
Technology Assessment
Global Warming
Evapotranspiration
Agroforestry
Modern Environmentalism
Common Spaces
Superfund

THE CONTEMPORARY ENVIRONMENTALIST PROFILE

Not long ago, being referred to as an "environmentalist" in American society signified radical behavior and an anti-establishment perspective on most issues. This perception is being replaced with a whole new array of characteristics. See Figure 10.2. Across the United States, Americans' concerns about their environment are increasingly being expressed through the all-inclusive yet somewhat elusive phrase—"quality of living."

The quality of living concept carries slightly different meanings from one person to another or from one geographic region to another. Consistency among these environment definitions can generally be found within the universal values of clean air, pure water, and an appreciation of the diversity of the natural environment. It seems many individuals have come to expect these items as a part of their birthright. However, they also realize these values are being threatened by technology.

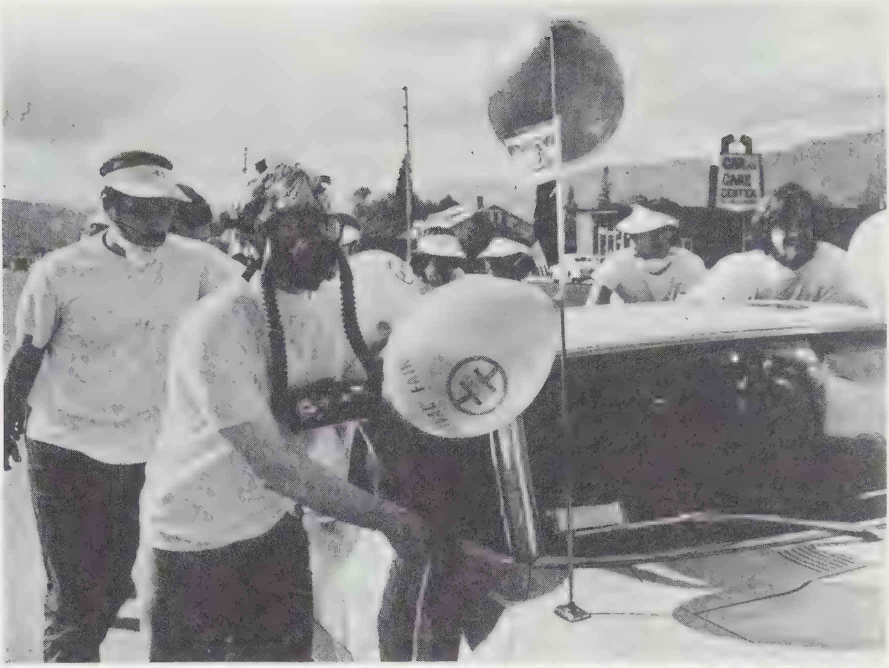


Figure 10.2 In order to recognize the nation's first Earth Day and support environmental protection legislation, these students purchased a 1970 Maverick from a local auto dealership. They pushed the car approximately 15 miles to its burial plot on the San Jose State University campus. As they rolled it into a deep trench, all its windows were shattered, the air let out of its tires and the interior was filled with dirt. Notice the student in the foreground who donned a gas mask to illustrate his opinion of the air quality in his home town.
(Spartan Daily Newspaper, San Jose State University)

Daily newspapers continually bring revelations of a toxic spill, hazardous material incident, or a natural resource in jeopardy to our doorsteps each morning. The disheartening nature of these reports, coupled with the desire to live in a "quality" environment, has prompted an eagerness on the part of the general public to correct these situations. Being called an environmentalist today no longer connotes counter-cultural viewpoints!

ENVIRONMENTALISM

Modern ENVIRONMENTALISM is a term used to describe an information-based perspective that supports the need for harmony between industrial objectives and environmental goals. First of all, the modern environmentalist recognizes environmental goals cannot be pursued without regard to their consequences elsewhere. For example, effective energy policy cannot be based solely on environmental values. A clean environment is only one of the many results we want in the development of a national energy policy. A clean environment is not the central driving force. The second component of the modern environmentalist perspective involves the realization that it is both necessary and possible to minimize the destructive environmental side-effects of technological progress through careful assessment and planning.

The key phrase in the above description is "information-based." The number of environmentalists who suffer from chronic parochialism (narrowness) today seem to be in the minority. Environmental rhetoric is gradually being replaced with scientific/technical data accumulation resulting in reflective and systematic decision-making. In other words, a brainstorming session between upper management and the production workers in a manufacturing firm regarding their safe and effective storage/disposal of toxic solvents is more indicative of contemporary environmentalism than the bumper-sticker that reads: "You Choose: Cancer or Clean Air!"

Industrialists and environmentalists alike have mellowed with age. Neither faction in this struggle has a monopoly on virtue. Both groups create opportunities to enhance our standard of living. Both groups also create problems challenging our ingenuity and willingness to confront changes. Together these individuals have begun to consider options to stimulate technological development and simultaneously strive to preserve the natural environment. Take a moment to reflect on the Coyote Valley events described in the DATELINE segment of this chapter. Although the saga of a single butterfly species may seem insignificant among numerous other more serious environmental issues, it illustrates that it is possible for environmentalists and industrialists to sit together on the same side of the bargaining table.

PUBLIC SUPPORT OF THE MOVEMENT

In many countries,the viability of public programs, political platforms, and social movements is very dependent on a strong measure of public support. One of the more remarkable aspects of the environmental movement in the United States has been the durability of public support for its programs, projects and proposed regulatory legislation. Despite the fact many sociologists and politicians predicted public interest in ecology would fade as soon as some other "cause" surfaced on the scene, its support for environmental programs is still strong. Widespread dissatisfaction with the social costs of careless technology moved environmentalism from a concern of a few individuals to an accepted truth among the populace.

Regardless of support, most people do not identify pollution, tropical forest resource management, and other environmental issues as the most serious tasks at hand for our nation's administration. World peace and economic concerns are more commonly found to overshadow environmental protection as national priorities. This tendency does not necessarily detract from the strength of the environmental movement or the extent to which people demonstrate personal interest in its programs. It merely connotes that the environmentalist movement has gone through a process of maturation and has achieved a credible position on our country's political agenda.

Another measure of public support for the environmental movement can be gleaned from the membership rosters of several influential environmental organizations. Whereas the number of members who contribute to the organizations remained somewhat stable throughout the environmental decade of the 1970s, the Sierra Club and the Wilderness Society both doubled their memberships during the early 1980s. Active participation in smaller organizations such as Friends of the Earth and Defenders of Wildlife has also increased significantly in recent years. Furthermore, these organizations have begun to receive strong verbal backing from many American citizens who are not even actual members.

On a less optimistic tack, public interest in environmental policies may have waned over the past few years due to excessive legalistic jargon. The modern environmentalist movement is heavily shrouded by an overt interest in the law and its administration. The National Environmental Policy Act (1969) established a set of guidelines that federal agencies must follow before they undertake any significant action. Subsequently, a network of federal laws, supported by amazing volumes of regulatory materials, have been created to protect the air, water, land, and seas—at least on paper! This legalistic character of modern environmentalism has brought steadiness, resources, and power to the movement. But it may also be responsible for disrupting a certain degree of public interest in its principles.

A major problem confronting the leaders of this movement may center on how to recapture the energy of the American public in a new commitment toward improving environmental quality. The fact that government has taken such an active role in environmental affairs has possibly created the sentiment: "Washington is handling that." Many persons may feel their vote for an environmental initiative (clean water, hazardous waste sites, etc.) on the ballot is the largest and often final measure of support needed to get things going in the right direction.

Recognize it is not enough to be sensitive to environmental issues as some public opinion surveys seem to surmise. Support for the environmental protection movement must be personified through actual changes in behavior. This change is often difficult for many of us. A case in point to illustrate this brings to mind a small screen printing shop in central Pennsylvania during the mid-1980's. The proprietors expressed verbal support for the safe use of cleaning solvents among their employees. However, they did not seem overly concerned about their casual disposal of methyl ethyl ketone (MEK) onto the company's parking lot.

It is quite possible this isolated situation has since been corrected. Many of the global issues discussed in the following section may very well have originated at such a seemingly innocent and localized site. If the present environmental movement expects to make any sort of dent in devising solutions for these problems, then active public support must be reignited at the "grass roots" level throughout the world.

KEY ISSUES ON A GLOBAL SCALE

The United States is confronted with numerous international environmental issues that essentially fall into three general categories. These are:

1. Handling domestically important issues that require the cooperation of other nations to solve.
2. Dealing with areas of the world under some sort of international jurisdiction.
3. Assisting less-developed countries contend with their seemingly localized environmental problems.

The extent to which progress is imminent in any of these areas is still questionable.

INTERNATIONAL COOPERATION

There are an increasing number of technological by-products which pose a threat to the stability and quality of the United States environment that can only be dealt with on an international level. Potential menaces to the global climate such as ozone depletion and carbon dioxide build-up are the clearest examples. Strategies enacted by the United States alone will be insufficient to deal with these problems. The magnitude of these dismal trends requires a concerted, cooperative action by a number of national governments.

The track record of accomplishments over the past couple of decades justifies optimism, albeit qualified, regarding the ability of nations to cooperate on international environmental issues. Joint efforts have occurred in marine navigation, air quality, public health, and agricultural practices. Specifically, a large number of international treaties of major environmental significance have been initiated. Many of these have only recently begun to seriously take effect (Bonn Convention on Conservation of Migratory Species of Wild Animals [1979]; Convention on Wetlands of International Importance [1971]; International Treaty on Long-Range Transboundary Air Pollution [1983]; Vienna Convention for the Protection of the Ozone Layer [1985]).

Besides these recent agreements, older international treaties have been given renewed significance due to the growth of concern for the environment. The Boundary Waters Treaty that was signed between the United States and Canada nearly eight decades ago has been applied to a growing number of present-day environmental issues. Although much still remains to be achieved in order to improve the quality of water in the Great Lakes, some observable progress has been made. On another border, water quality agreements between Mexico and the United States have updated a 1945 treaty via the more recent construction of a large desalinization plant on the lower Colorado River.

The most notable progress in international cooperation appears to have been made through multinational scientific investigations. Scientific programs organized through specialized agencies in the United Nations have been implemented cooperatively with various international scientific and technical associations. The International Council of Scientific Unions (ICSU) has been most effective in launching these ventures.

If one reviews the direction of international cooperation rather than the actual results of the above described projects, there is more reason for optimism. Recognize some governments have been willing to sign treaties or adhere to international programs wherein very little follow-up action was expected or required. Futhermore, in those environmental agreements where decisive activities were accepted among the signatories, implementation has not always followed. In many instances, the inertia of human behavior has been detrimental to full-scale progress in solving global environmental problems.

It is atypical for people, as well as political entities, to plan for living more than a few years into the future. On the other hand, we must begin to act with a view toward future consequences in order to solve today's environmental problems. Some researchers project it is already too late to bring serious and often dangerous situations under our direct control.

Acid precipitation is a major environmental concern in over a dozen industrial nations, but very little action has been taken to alleviate the problem. International business in agriculture and forestry are altering the ecosystem of the Earth quite rapidly. Unfortunately, affected nations have been unable to control these changes in ways that will allow the advantages of technology to be retained without destroying the riches of the natural environment. Effective environmental policy (as well as international cooperation) requires a type of foresight and benevolence for future generations that is often rare in society.

INTERNATIONAL JURISDICTION OF COMMON SPACES

Several regions of the world are regarded as "common spaces" and are either in whole or partially considered international territory. These areas are becoming increasingly significant as more is learned about their potential as sources of strategic raw materials. Areas presently beyond national jurisdiction include: the open ocean outside a 200-mile territory adjacent to coastal regions and the sea beneath; the extra-terrestrial space surrounding the Earth; and the continent of Antarctica.

Balancing environmental concerns with the economic advantages of technological development and/or exploitation continues to be a major issue for these areas. Up until recently, these areas were customarily regarded as belonging to no one and the common availability of their usage was not debated. Advancements in technology have subsequently created a scenario wherein the natural resources indigenous to these areas can be more readily pursued. Even still, no general agreement for the governance of these regions has been reached. Perhaps this is due either to the fact that, (1) the environmental problems and opportunities that these areas present are very unfamiliar, or (2) the ability of nations to explore, occupy, or exploit these regions differs a great deal. Only a few technically advanced countries presently have both the economic and technological capacities to conduct research activities on the ocean floor, in Antarctica, or in outer space.

The **Law of the Sea Treaty** was sponsored by the United Nations and was negotiated over a 14-year period commencing in the late 1950s. This agreement provides for an international authority to license and regulate deep sea mining and to allocate a share of any of the potential profits among less advantaged countries. Several governments, including the United States, have expressed dissatisfaction with this arrangement. Although there is no general governance in place for the high seas, treaties to prevent ocean dumping and other forms of marine pollution have been ratified. Proposals regarding the protection of whales and other marine life species have also been negotiated.

The fact that not all nations who possess maritime capabilities are party to these treaties creates the potential for oceanic resource depletion/degradation. Even though some measure of progress has been made toward international responsibility for the oceanic environment, its future viability remains vulnerable to pollution and exploitation. Nations who place their immediate economic interests ahead of a marine environment characterized by richness and diversity pose the greatest danger in the upcoming years.

Similarly, **outer space** has no general governing body. It is unlikely that one will be established in the near future. The penetration of outer space by artificial satellites and manned vehicles after the close of the 1950s decade opened a new domain for possible national jurisdiction.

A body of proposed "space law" rapidly appeared on the scene. Specific aspects of outer space were subsequently governed by treaties concerning telecommunications, remote sensing, and military uses. The United Nations sponsored a general treaty in the late 1960s which favors the peaceful use of outer space. Conversely, present military proposals among leading industrial nations make future agreements regarding the integrity of the outer space environment seem improbable.

Antarctica presents a case where the time to choose between international cooperation or conflict has most definitely arrived. The continent has been treated as a scientific reserve since the Antarctic Treaty of 1959. It has been maintained in its natural state without permanent occupancy, resource development, or pollution. The terms of this treaty have been administered by a consultative committee of nations and are due to be reconsidered very soon.

At the time of the initial signing of the Antarctic Treaty, technological capabilities were insufficient to justify economic interest in this unique environment. Today, due to the prospect of future demands for minerals, continuance of Antarctica as a protected state is dubious. The United States and several other nations have begun to reinvestigate Antarctica's resource potential. It seems that the fate of the continent, together with the marine life of the surrounding seas, may be at stake before the end of the century.

Unlike other nations, the United States government recognizes no national claims to Antarctic territory and makes no claims of its own. Not surprisingly, it also possesses the greatest fund of knowledge, experience, and technological prowess essential for Antarctic resource development. Therefore, it seems the United States is in the proverbial driver's seat with reference to Antarctica's future status in the international community. The directions for development here will be toward either a reserve for scientific cooperation or an arena for international conflict.

PROVIDING ASSISTANCE FOR DEVELOPING NATIONS

Helping less-developed nations to deal with the enormous environmental problems they face is no longer a simple matter of morality or altruism (regard for the interest of others). Environmental degradation in Third World countries has very direct implications for the United States. Specifically, ecological/environmental instability contributes greatly to political instability in many areas of the world.

Unmanaged population growth outstrips the capacity of less-developed countries to support their people. Uncontrolled soil erosion undermines a community's capability to provide enough food for its residents. Unmonitored forest destruction deprives the local population of raw materials needed for fuel and shelter. Citizens who must confront these problems on a daily basis represent a potential source of revolutionary discontent. It ultimately becomes difficult, if not impossible, to address the question of environmental protection when your own survival has no assurance.

Haitian immigrants are not only refugees from politics, they also left behind a country whose land has been virtually destroyed. In many areas, 50 percent of the land surface has eroded to bare rock and there are no forests left on the island. Jamaica provides another example. Massive emigration from this country is due in part to the deterioration of their natural resources.

In South America, the high Andean mountain regions are suffering perilous soil erosion since traditional systems of agriculture have all but disappeared. Developmental aid in the 1950s and 60s was devoted to the introduction of cash crops for export in order to attain the foreign currency needed to develop industrial centers. Many of these crops were not suitable to the soil. Likewise, the undermining of traditional farming practices in the Sahel region of West Africa has caused severe environmental problems.

Some years before armed conflict broke out in El Salvador, scientific/technical observers noted problems of deforestation, soil erosion, stream siltation, and the harsh effects of fuel-wood harvesting on natural vegetative recovery. Air and water pollution were not monitored and the birthrate ultimately exceeded the capacities of existing health, education, and welfare programs. Social-ecological decline eventually prepared the ground upon which subsequent social wars have been fought over the years.

Despite these worsening problems and the underlying threat for international stability, governments seem to be unable to effectively come to terms with them. The tendency has often been to delay the implementation of long term solutions in exchange for improvisational decision-making. This form of stopgap measures is best described as crisis management.

It should be apparent by this point in time that developing nations, as well as industrial leaders, must prevent environmental problems from arising rather than continue to work at cleaning them up afterward. However, the adoption of anticipatory environmental policies is certainly not easy. This type of action is required *before* damage to the environment has created a demand for it and tends to be more the exception than the rule. The remaining sections of this chapter will discuss three general areas of extreme environmental importance in the United States and the world community: Atmospheric Quality, Tropical Forests, and Waste Management.

AIR QUALITY STANDARDS

The central goal of the monumental Clean Air Act and its subsequent amendments has been to manage air quality to protect human health. It was the first of the major environmental regulations adopted in the United States. This legislative decision required the U.S. Environmental Protection Agency (EPA) to establish strict limits on several major pollutants existent in industrial centers including sulfur oxides, nitrogen oxides, and particulate matter. These limits were set at the federal level during the early 1970s. As a result, this environmental law has been the most costly one ever enacted requiring businesses to bring their production facilities into compliance. Estimates made by the Council on Environmental Quality place the total annual cost of complying with the Clean Air Act over $20 billion nationally.

In terms of the pollution problems caused by the types of pollutants regulated in this federal act, air quality in the United States continues to improve. Throughout the 1970s, the number of days when air quality in densely populated areas reached harmful levels declined by at least one third. Since many areas of the country still continue to experience periods when air pollution levels create human health risks, the struggle is far from over. These tough areas of urban pollution (Los Angeles, Houston) may ultimately prove to be too expensive and difficult to clean up—however, optimists hope this is not the case.

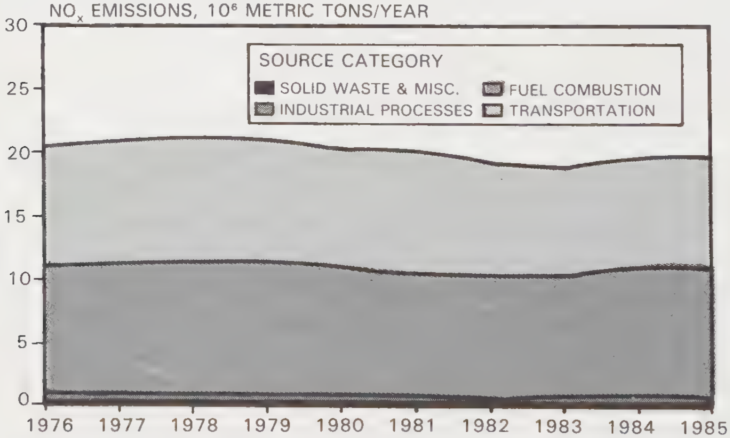
Additionally, other pollution problems having adverse effects on air quality are currently being noticed. Present control efforts do not effectively address these hazardous and other "nonconventional" air pollutants. Furthermore, existing sulfur oxide controls appear to be grossly inadequate to protect lakes and forests against the problems caused by acid rain. The relentless build-up of carbon dioxide in the atmosphere may spell disaster to global climatic stability. Finally, even though most Americans spend a majority of their time indoors, there are minimal (if any) efforts being made to control air pollution levels in these areas.

Procedures used to monitor air quality are not as reliable as some of the persons reporting "cleaner air trends" would have us believe. We do not have a national system for monitoring air quality. Instead, area monitors are operated by different states and localities across the country. The locations of these monitoring stations change periodically, records are often incomplete, and quality control practices are *not* always satisfactory.

On the surface, data may suggest air quality has improved significantly over a specified period of time. Recognize however that year-to-year improvements may occur for a variety of reasons not directly indicative of the success of pollution-control efforts. For example: a major source of pollution may have closed down and moved to another site where pollution levels are increasing; temporary economic slumps may have caused an equally short-lived reduction in industrial emissions; or, more favorable climatic conditions may have developed with steady breezes dispersing the pollutants elsewhere. Since monitoring data are not usually adjusted in consideration of these variables, caution should be exercised in the overly optimistic interpretation of air quality changes on a yearly basis. Generally speaking, it takes more than a year or two to substantiate a "trend" in any field of study.

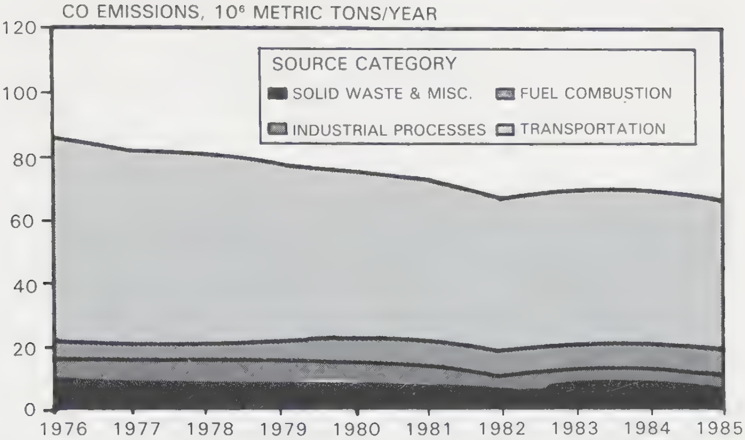
AMBIENT AIR QUALITY

National efforts to control air pollution have commonly been focused on improving ambient air quality in high technology/urban centers. The six "conventional" pollutants toward which most of the attention has been directed include: total suspended particulate (TSPs), sulfur oxides, nitrogen oxides, carbon monoxide, lead, and ozone. Numerous industrial emitters of these pollutants have subsequently switched to cleaner fuels and have adopted control technologies such as electrostatic precipitators. EPA estimates that emissions of the "conventional" pollutants from most of the major sources have declined or held steady since concerted clean-up efforts began in the early 1970s. Refer to the charts shown in Figure 10-3.

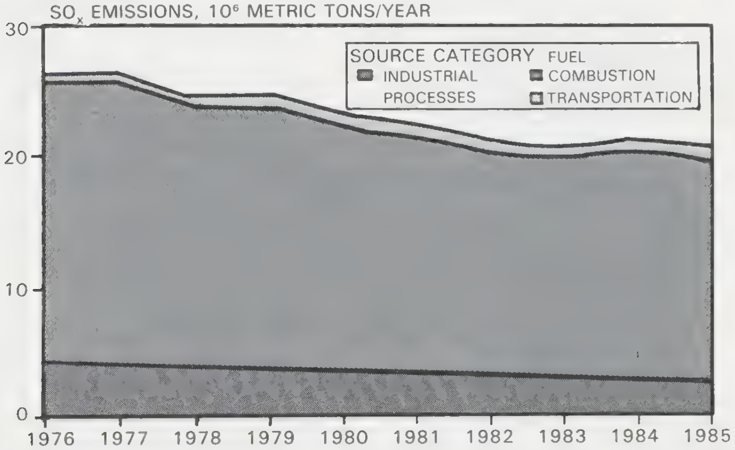


National trend in emissions of nitrogen oxides, 1976-1985.

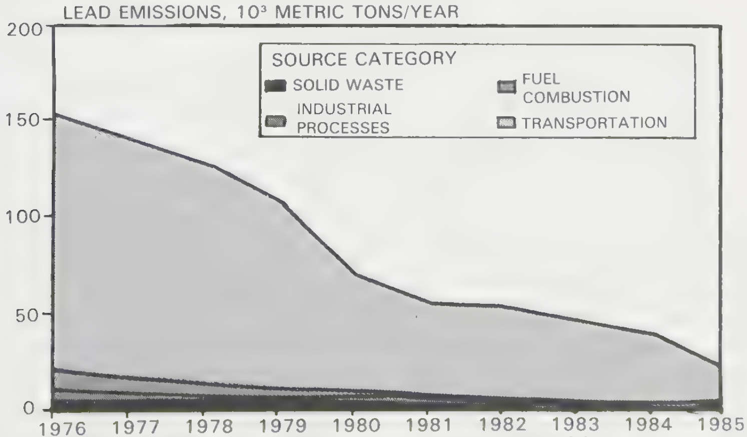
Figure 10.3 Trends in ambient air quality for six pollutants. (U.S. Environmental Protection Agency)



National trend in emissions of carbon monoxide, 1976-1985.

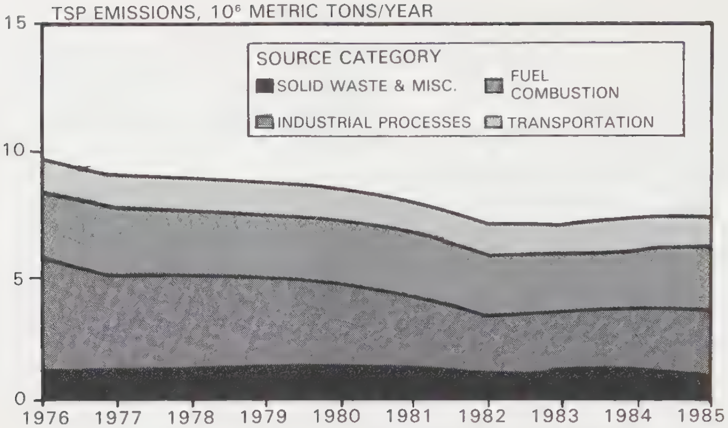


National trend in sulfur oxide emissions, 1976-1985.

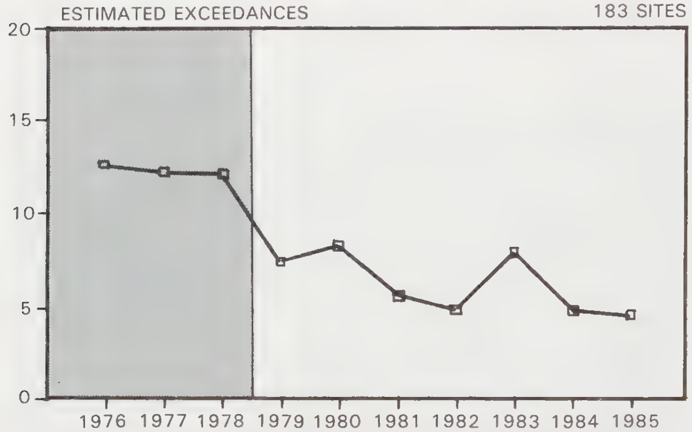


National trend in lead emissions, 1976-1985.

Figure 10.3 Continued.



National trend in particulate emissions, 1976-1985.



National trend in the composite average of the number of days when the amount of Ozone (O_3) exceeded the National Ambient Air Quality Standards (>0.12 ppm) 1976-1985.

Figure 10.3 Continued.

The **Pollutant Standards Index** (PSI) was developed by the EPA in cooperation with the Council on Environmental Quality in an attempt to standardize air pollution reporting. This index supposedly enables comparisons to be made between different regions of the country. The PSI converts the concentrations of several commonly occurring pollutants to a simple number between zero and 500. Conversion tables are available for ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide, total suspended particulates (TSP), and coefficient of haze (COH). See Figure 10.4.

The index value of 100 represents the concentration for each pollutant below which adverse health effects have not been observed. It was selected to correspond to the short-term (24 hours or less) National Ambient Air Quality Standards set by the EPA. The highest PSI value of 500 corresponds to the significant harm level as the concentration of each pollutant that should never

PSI CONVERSION TABLES

Descriptors	Range	Ozone 1-hr, ppm	Carbon Monoxide 8-hr, ppm	*TSP 24-hr, $\mu g/m^3$
Good	0-50	.00-.06	0-4.5	0-75
Moderate	51-100	.07-.12	4.6-9.0	76-260
Unhealthful	101-199	.13-.19	9.1-14.9	261-374
Very Unhealthful	200-299	.20-.39	15.0-29.9	375-624
Hazardous	300 & above	.40 +	30.0 +	625 +

*TSP derived from site-specific and season-specific Coefficient of Haze (COH) values

Figure 10.4 Pollutant Standards Index (PSI) conversion tables. (Bay Area Air Quality Management District, EPA)

be reached. State and local agencies are required to take emergency action to prevent air pollution from ever reaching this level (temporary restriction of automobile traffic or manufacturing processes). On the average, ambient air quality in United States metropolitan areas, as measured by the Pollutant Standards Index has been improving consistently since the early 1970s. The table presented in Figure 10.5 reveals the extent to which air quality has for the most part improved (+ numbers) and in a few cases worsened (− numbers) since the early 1980s.

THE ACID RAIN DILEMMA

Acid precipitation results from the presence of sulfur oxides and nitrogen oxides in the atmosphere which then react with moisture to form dilute sulfuric and nitric acids. These resultant aerosols are eventually carried back to earth as rain, snow, fog or dry particles. In some areas the acid is “buffered” by the earth’s natural alkalinity and apparently causes little damage. In other locations however, the acid either reacts with soil and leaches away important nutrients, or it drains off the land and accumulates in lakes and ponds. The ecosystems of these bodies of water are then severely disrupted and many of them “die” and become unable to support aquatic wildlife of any type.

In recent years, acid rain has received widespread recognition as a serious environmental problem in many parts of the world including Canada, Scandinavia, Japan, and the Northeastern United States. However, there does seem to be a certain amount of scientific controversy regarding the extent to which acid rain is actually the sole culprit in these scenarios. Scientists have been systematically monitoring the evidence about acid rain’s environmental effects since the mid-1970s. Scientists often indicate acid rain is only a minor contributor to the environmental damages for which it has been blamed. In other words, claims regarding acid rain damage have been based on circumstantial evidence and are still somewhat misleading.

PERCENT CHANGE IN AIR QUALITY TREND STATISTICS
1981 TO 1985

		TSP	Pb	SO_2	CO	NO_2	O_3
	National	−18	−49	−15	−17	−5	−3
East	Boston	−6	−54*	−26	−23	0	+33
	New York	−9	−64*	−16	−18	+1	−8
	Philadelphia	−19	+6	−21	−29	−2	−5
	Baltimore	−13	−53	−26	−20	+9	−5
Midwest	Detroit	−15	−60	−27	−24	−16*	−24
	Chicago	−25	−56	−18	−35	−23	+4
	St. Louis	−27	−54*	+14	−24	−9	+3
South	Atlanta	−17	−63	—	−33	—	−4
	Houston	−33	−66	+16	−16	−22	−3
Southwest	Denver	−10	−42	−31	−13	+3	−12
	Phoenix	−18	−63	−41	−32	—	−6
	Los Angeles	−15	−65	−24	−8	−14	0
Northwest	Portland	+8	−45*	0	−26	—	−6
	Seattle	+2	−76	−10	−16	−18	−13
	Weighted Average**	−17	−50	−15	−20	−12	−4

*Extrapolated 5-year trend based on 4 years of data.
**Weighted by number of monitors in each city for comparison to national average.

Figure 10.5 Percentage change in air quality trend statistics 1981 to 1985. (Environmental Protection Agency)

The United States federal government established a National Acid Precipitation Assessment Program (NAPAP) in 1980. It was commissioned to make every serious effort to determine the degree to which acid rain *may* be responsible for certain environmental problems. Earlier research attempts usually *assumed* that acid rain was the cause of the damage at hand and proceeded to ascertain how the actual process of degradation worked. NAPAP scientists have designed their research around three main questions regarding the acidification of U.S. lakes:

1. Has there been a significant increase in lake acidity?
2. Might something other than acid rain be contributing to lake acidification?
3. Might something other than acidity be affecting the survivability of the fish?

Retrieving straightforward, reliable answers to these questions has not been easy. There still does not appear to be any scientific consensus on this issue.

Several other accusations have been leveled against acid rain including its detrimental effects on human health, crops, forests, and building materials. NAPAP personnel are still working on projects devised to determine the extent to which these claims are valid. Some of their preliminary evidence suggests we can reject the concept that acid rain causes premature deaths among humans. Also interesting, NAPAP experiments regarding crop damage have led the Environmental Protection Agency to conclude the effects of acid rain on crops are as likely to be positive as negative but are minimal in either case.

Most of the NAPAP analyses dispute the viewpoint that acid rain substantially degrades exposed structures and building materials. They suggest natural weather conditions such as freeze-thaw cycles coupled with a variety of air pollutants cause the observable damage. More importantly, NAPAP scientists have found most urban pollution comes from local emissions rather than from distant emissions borne by rainfall. It therefore seems likely we should focus on local automobiles and nearby industries in order to reduce the impact of pollutants on urban area structures.

None of this discussion is meant to imply acid rain is *not* an air quality problem that demands some sort of immediate action. On the contrary, long-range correlational studies are being conducted in an attempt to provide a clearer avenue for action and effective investment of funds. The "scientific jury" seems to be unsettled in presenting its verdict in this dilemma.

UPPER ATMOSPHERIC PROBLEMS

Some of the more potentially serious air pollution problems are not even occurring near the earth's surface. The upper atmosphere has been selected as a "laboratory" where a dramatic technological experiment is taking place. For over a century, scientists have been debating over what will occur as a result of loading a large amount of carbon dioxide (CO_2) and several other gaseous elements into the earth's upper atmosphere. Some degree of agreement among them has evolved over the years and trends toward global warming seem quite probable and possibly irreversible.

Carbon dioxide (CO_2) in the atmosphere has unquestionably increased over the past several decades. These increases are the direct result of human activities largely related to industrialization and the advancement of technology. Specific examples of the types of activities that have contributed to the CO_2 build-up include the combustion of a greater number of fossil fuels and tropical deforestation (discussed further in the following section). If the production and use of fossil fuels continues to increase at the same rate, projections indicate CO_2 concentrations in the atmosphere will double preindustrial levels by the mid-twenty-first century and will lead ultimately to severe changes in global climate.

While it is not totally clear how an increase in the mean global temperature will affect weather patterns, some scientific analyses have been made. Various studies have surmised the build-up of CO_2 could eventually melt the ice-cap at the North or South pole, leading to a rise in sea level which would drown out many coastal cities. A small change in the mean global temperature could cause large shifts in weather patterns creating a higher frequency of droughts, hurricanes, freezes, and floods. A decrease in annual rainfall within the world's prime agricultural belts, coupled with other losses of water from rivers and foliage, could virtually ruin the productivity of some of the most fertile acres of land on earth.

If climatic changes are brought about by warming, they will most likely start occurring during the lifetimes of roughly half of the people alive today. Although it is easy to envision the dates 2035 or even 2050 as excellent movie titles, they do have a certain unrealistic quality to them. Even something closer at hand—perhaps the possibility that the Great Plains area of the United States will experience back-to-back years of droughts in 1996—commands less attention than the dollar's robustness in the international money market. What should the government's policy response to CO_2 be and what sort of research in this environmental area needs the greatest financial backing?

An issue like the "greenhouse effect" of global warming requires Congress to look decades ahead. This legislative branch of our government is typically against solving long-term problems. Many lawmakers seem to be unable to think ahead more than a couple of years.

At the very least, it is imperative to embark on an energy conservation program that would also encourage the development of other energy sources less likely to increase atmospheric CO_2 levels. There should be more research into the climate dependencies of various staple crops, and farmers should be encouraged to use water more efficiently. Irrigation projects and large-scale water supply networks should take into account the possibility of future shifts in rainfall patterns. International reforestation programs are essential and countries like Brazil and Malaysia should be admonished to discontinue the destruction of their rain forests.

INDOOR AIR QUALITY

It is becoming obvious air pollution is no longer an exclusively outdoor problem. Concentrations of air pollutants such as carbon monoxide, radon, formaldehyde, asbestos, and passive tobacco smoke are often far greater inside buildings than outside. Since people spend a bulk of their time indoors, these pollutants pose a significant health threat.

It may be time to establish a formal indoor air quality monitoring program similar to the ones devised for outdoor air at the federal, state and local levels. Several factors indicate indoor air quality may be worsening. Ironically, energy conservation practices in homes and office buildings tend to reduce the escape of indoor air and allow pollutant concentrations to increase. The increasing popularity of burning alternative fuels such as wood and kerosene in the home is responsible for the release of numerous hazardous pollutants. Additionally, the use of synthetic chemicals like formaldehyde and volatile organic resins in home construction and furnishings can have toxic effects on humans.

The relationship between concentrations of indoor and outdoor pollutants is further complicated by wind speeds, architectural designs, and ventilation systems. Structures with forced ventilation to the outside or natural ventilation via open doors and windows will have roughly similar pollutant concentrations inside and out. Many new buildings are designed with reduced air infiltration. Reducing the number of air exchanges between inside and outside lowers heating and cooling costs but simultaneously increases the concentrations of the indoor pollutants listed above.

Historically, regulatory strategies concerning air quality in the United States have centered on the concentrations of ambient or surrounding pollutants. This approach has involved the measurement of outdoor pollution levels at particular locations. These indices are then assumed to be the primary determinants of exposure for the people residing in that area. It is obvious this procedure is far from being comprehensive. Further research into indoor air quality programs is necessary if human health risks associated with air quality are to be accurately assessed.

TROPICAL FOREST RESOURCE DEPLETION

Scientists and world leaders consider tropical deforestation to be one of the earth's most serious environmental problems. The longevity of their concern combined with the current tropical forest destruction rate provides undeniable validity for this apprehension. The term tropical forest refers to forests in the humid and semi-arid or arid regions of the world. Forests ranging from moist (or closed) tropical forests to dry (or open) woodlands are generally included in the description.

The destruction of tropical forests in the world today is so extreme and so devastating that humanity may very shortly lose its richest, most diverse, and most valuable biotic resource. The damage being done may not be entirely visible to those of us who reside in the United States since the "tropics" are far-away lands about which we know very little. For many people, the word "tropics" brings to mind a picture of pristine nature, mysterious ceremonies, large mammals, and exquisite orchids and palm trees. The scene is quite reminiscent of old movies and is difficult to authenticate anywhere in the continental United States.

Once thought to be limitless and expendable, a renewable resource so to speak, the rain forests are presently disappearing at an alarming rate. Estimates of exactly how much rain forest is being lost or irretrievably changed tend to range from 20 million to 50 million acres per year. This represents approximately one to two percent of what is still left standing. Moist tropical forest lands encircling the earth's equatorial sector cover approximately 6 percent of its surface area. Just since the end of World War II, nearly half of this rain forest has been destroyed in the name of logging, farming, ranching, mining, and road building.

What has been lost already is literally irreplaceable. Contrary to the popular cliche, the jungle does not reclaim its own. Even where a healthy second growth manages to come back, the species it breeds are not the same as those previously in existence. The primal tropical rain forests reach back through evolution. Its brilliant flora and fauna reflect continental drifts and the ebb and flow of ice ages. Scientists project that well over a million species of plants and animals could be extinct by the turn of the century as the forests are continually degraded. Furthermore, if the current pace of exploitation remains unchecked, the rain forests will have vanished forever within the next several decades.

IMPORTANCE OF TROPICAL FORESTS

For some 2 billion inhabitants of the world's tropical nations, the forests provide fuel, food, medicines, building materials, wood for lumber and paper, and many other basic needs. Forests help to maintain soil quality, limit the erosion process, stabilize hillsides, modulate seasonal flooding, and effectively protect nearby waterways from accelerated siltation. The tropical forests can also represent an important source of foreign exchange, export revenue, and employment for local residents.

The potential benefits acquired from tropical forests are not limited solely to the tropical nations. World trade in tropical wood is significant to the economic prosperity of both the producing and consuming nations. The United States is one of the largest importers of tropical wood and wood products. Its demand has been growing steadily over the past couple of decades.

Tropical forests also provide a broad array of nonwood products including oils, spices, and rattan. These items are valuable for both subsistence and commerce alike. The annual world trade in rattan, and the oils and spices extracted from tropical plants exceeds $2 billion. Some of the more familiar oils and spices found in many American homes include camphor, cassia, cardamom, citronella, and cinnamon. Thus, the export of industrial wood and nonwood forest products earn substantial foreign exchange for nations trading with the United States.

A cursory glance through the contents of the typical American family household's medicine cabinet provides further verification for the importance of the tropical rain forests. The wide array of rain forest plants and animals provide at least one fourth of the ingredients needed to produce the prescription drugs on the market today. The snakeroot plant of India's monsoon forests yields reserpine which is an alkaloid providing the base for many tranquilizers. The corkwood tree of eastern Australia provides scopolamine—a drug used in the treatment of schizophrenia. In the Amazon basin one finds the plant derivative curare which is an essential agent for treating Parkinson's disease. There are research biologists who estimate that over 1000 plants found in the tropical forests may have potential anticancer properties!

The agricultural stability of the United States is also directly related to the existence of tropical rain forests. These regions provide habitats for many of the world's migratory birds and various endangered avian species. Approximately two-thirds of the birds that breed in the North American continent migrate to Latin America or the Caribbean for the winter season. Some of these birds play a significant role in controlling agricultural pests found to afflict United States farmlands. Depletion of their tropical habitats may ultimately spell their extinction.

The tropical forests are also critical to the economic viability of United States investments overseas and, as previously mentioned, to the political stability of developing nations. For example, United States foreign assistance programs (technical as well as financial) can be erratically disrupted by flooding, siltation, and other environmental damages caused by deforestation. Inappropriate deforestation practices also reduce food sources and jobs, both of which are necessary to maintain political stability in these countries. The flow of refugees from Haiti to the United States was cited earlier as an example of economic and social unrest caused, at least in part, by tropical deforestation.

In sum, the tropical rain forests represent the planet's "biological warehouse" where the diversity of plant and animal life found within a single acre plot is simply staggering. Destroying these rain forests means losing 80 percent of the world's vegetation and up to 4 million varieties of life forms, many of whose benefits are still unknown.

CAUSES AND CONSEQUENCES OF TROPICAL FOREST DESTRUCTION

The United States Office of Technology Assessment was commissioned to conduct a thorough analysis of the problems akin to tropical deforestation and a review of the technologies that could possibly help sustain tropical forest resources from further depletion. Following several years of investigation, their final report was completed and submitted to Congress in the mid-1980s. These researchers stress the main causes of forest destruction and degradation stem from the following situations: rapidly rising populations require more land for food production; primitive methods of agriculture which produce low yields and ruin soil fertility; and the chronic failure of political institutions to execute programs with an eye for long-range prosperity.

In parts of Latin America, encroachment on the forests is simply a response to social pressures where a vast majority of the arable (fit for cultivation by plowing) land is controlled by a very slim percentage of the population. Millions of Central American inhabitants do not have enough land to provide for their subsistence. Government officials subsequently view the land currently covered by forests as the answer to overcrowded conditions and extreme levels of poverty among their constituents.

Starting sometime in the mid-1970s, vast tracts of Central American forest were cleared for ranching. One stimulant for this activity, which destroyed some 8000 square miles annually through the 1980s, came from the United States demand for low-cost ground beef and pet food. It is doubtful very many Americans consider the environmental consequences of tropical deforestation when they feed their dogs or purchase a deluxe hamburger at their neighborhood fast-food establishment. The most unsettling aspect related to this particular "economic" activity is found in the short life span of these grazelands. The "slash and burn" methods of cultivation used limit its productivity cycle to a period of three to five years. On the average, pastures become severely degraded and heavily weed infested within five to ten years after they were initially developed. In other words, the tremendous investments required to develop pasture in tropical forest regions are not justified by the short-term yields acquired.

Elsewhere in the Third World, the simple need for fuelwood, together with logging by international corporations, is denuding (stripping of covering) tropical rain forests. Nigeria has lost more than 90 percent of its forest cover and the forests along Brazil's Atlantic coastline have been cut to less than 2 percent of their former acreage. Traditional timber producers including Malaysia, Thailand, and the Philippines may soon face the prospect of becoming timber importers themselves due to excessive logging ventures.

The potential costs of tropical deforestation discussed in the scientific and technical literature seem to fall into three general categories including:

1. Severe changes in global weather patterns.
2. Loss of cultural and biotic diversity.
3. Desertification of the forest lands.

Stated more dramatically—in less than 100 years, Siberia could be the breadbasket of the world, New York City might be at the bottom of the sea, and one fourth of all existing wildlife species may be extinct.

Due to the vastness of the tropical rain forest segment of the planet, its loss poses an extreme threat to global climatic stability. Scientists estimate the respiration processes of forest trees and plants return at least half of the rainfall that drops on it back into the air. Conversion of the rain forest to pasture drastically reduces the evapotranspiration (refer to Chapter 1 for the definition of evapotranspiration) cycle. For instance, as the South American forest shrinks, the Amazon basin could dry out irreversibly, grow warmer, and shift weather patterns in the United States and Canada pushing the grain belt northward.

There is also a growing concern about the contribution of deforestation to the so-called "greenhouse effect" (the heating of the earth due to increased levels of carbon dioxide which traps solar energy in the atmosphere). The dramatic climatic effects related to an atmospheric build-up of CO_2 were discussed in a previous section of this chapter. However, there appear to be uncertainties about how much carbon is actually released as a result of forest clearing, as well as the amount of carbon dioxide taken in by healthy forests. Conclusions regarding this particular consequence of deforestation remain tentative.

Destruction of many plant and animal species is another serious consequence of tropical forest destruction. Many species of tropical rain forest trees live at low densities and lack seeds that are adapted to long periods of stressful environmental conditions. The species of plants and animals native to primary tropical rain forest conditions may be unable to recolonize large clearings or open areas.

In addition to the loss of entire species, we face the morally unforgivable prospect of ethnocide (death of a cultural group) of many small, isolated, and vulnerable groups of indigenous or local people. These individuals hold much of the knowledge and culture necessary to understand and utilize the rain forest's resources. Their obliteration and/or social displacement cannot be ignored in the throes of technological development.

As mentioned above, the bold razing of the tropical forests under the guise of farming and/or ranching produces only short-lived profits. The ash released from the burnt logs, initially a rich fertilizer, disappears quickly from the plot of cleared land. Denuded of its protective canopy and deprived of its fertile carpet of decaying plant life, the thin topsoil typical of these rain forests is soon washed away by tropical downpours.

The process continues for a few years until the land can no longer support human life. Farmers and ranchers then cut still deeper into the forest leaving behind desolate scrub land of near-desert conditions. Once the new patch of trees has been cleared, the torrential rains will once again erode the soil and further expand the problem of desertification.

TECHNOLOGY'S ROLE IN MANAGEMENT

In an era when environmental issues are of overriding importance to the well-being of society, the scientific and technological communities must focus their concern on those deemed most critical. Tropical forest resource management is an issue of great importance. It appears the technologies needed to abate the process of tropical deforestation do exist. Even still, significant inroads into the problem of deforestation and resource depletion have been slow to appear. There have been tremendous political, cultural, and economic constraints to overcome. Many of the actions needed to halt and correct forest resource deterioration can only come from the governments and citizens of the tropical nations themselves.

In light of this reality, the Congressional Office of Technology Assessment concluded the United States can still play a key role in sustaining tropical forests through its expertise in research, technology development, resource management, and education. It identified a number of existing and emerging technologies that could very well provide solutions to the crisis in the tropical rain forests. Some of these suggested actions include: farming techniques which combine trees with crops or livestock (agroforestry); genetic improvement of the trees; improved charcoal production; more efficient wood stoves; and new approaches to park design and management.

It may be true technologies developed in the United States can be used in the tropics. But it is critical they be adapted to their different climatic and social conditions. For example, while Landsat imagery already supplies vital information that could be used to improve tropical resource management, the primary constraint on its use is a lack of adequately trained personnel. Other technologies such as those for improved harvesting and handling of timber can also be modified for use in the tropics.

A recent international plan for specific actions to arrest and reverse tropical deforestation was sponsored by the World Bank, the World Resources Institute, and the United Nations Development Programme. This plan stresses the fact that tropical deforestation is an enormous problem but not an insoluble one. It proposed concrete, country-by-country strategies for the 56 nations most severely affected by tropical deforestation. These recommendations were accompanied by estimated costs of each program in each country over the next several years, Figure 10.6. If significant progress is made on these fronts, we can be hopeful some of the projections regarding the dire consequences of tropical rain forest destruction will prove to be erroneous.

Estimated costs* in million US$ for the period 1987-91

	Fuel-wood & agro-forestry	Land use on upland water-sheds	Indus-trial forestry	Eco-system conser-vation	5-year totals
Africa					
Botswana	15				15
Burkina Faso	25		–	–	25
Burundi	20	–			20
Cameroon	–	–	20	31	51
Cape Verde	15				15
Chad	14		-		14
Congo	–		20	–	20
Ethiopia	40	100	–	-	140
Gabon	–	–	–	13	13
Ghana	–	–	10		10
Ivory Coast	–	–	75	24	99
Kenya	48	35	-	–	83
Lesotho	10	–		-	10
Liberia		–	15	13	28
Madagascar	20	10	-	25	65
Malawi	24		–	–	24
Mali	30	–	–	–	30
Mauritania	16	–	–	–	16
Niger	20		–	–	20
Nigeria	50		35	–	85
Rwanda	30	–	–	–	30
Senegal	25	–	–	–	25
Somali	15	–	–	–	15
Sudan	35	–	–	–	35
Tanzania	30	–			30
Tanzania	30	–	-		30
Uganda	15	-	25		40
Zaire		–	10	24	34
Zimbabwe	–	46	–	-	46
Subtotal	507	191	210	130	1038
Asia					
Bangledesh	52				52
Burma	–		30	-	30
China	250	135	285	–	670
India	500	500	190	32	1222
Indonesia		100	50	43	193
Malaysia			40	34	74
Nepal	30	15	-	–	45
Pakistan	40	45	20		105
Papua New Guinea	–	-	15	10	25
Philippines		120	40	30	190
Sri Lanka	30				30
Thailand	-		35	28	63
Subtotal	902	915	705	177	2699

	Fuel-wood & agro-forestry	Land use on upland water-sheds	Indus-trial forestry	Eco-system conser-vation	5-year totals
Latin America					
Argentina	–	–	100		100
Bolivia	25		–	31	56
Brazil	400	10**	325	50	785
Chile		–	50	–	50
Colombia	–	50	45	30	125
Costa Rica	15		15	21	51
Ecuador	–	15**	20	17	52
El Salvador	10	–	–	–	10
Guatemala	–	–	15	–	15
Haiti	15	–	–	–	15
Jamaica	–	10**	10	–	20
Mexico	–	–	90		90
Nicaragua		–	–	17	17
Panama	–	20**	–	21	41
Peru	25	20**	30	36	111
Venezuela	–	–	25	20	45
Subtotal	490	125	725	243	1585
Total	1899 36%	1231 23%	1640 31%	550 10%	5320*** 100%

*All totals rounded

**Preliminary estimate, pending additional research

***Approximately 20% of this investment would be allocated to research, training, education, and extension.

Figure 10.6 Total investments needed to curtail the process of tropical forest resource depletion/destruction. (World Resources Institute)

HAZARDOUS WASTE MANAGEMENT

At thousands of hazardous waste sites across the United States, toxic chemicals are contaminating the land, air, and groundwater supplies. During the mid-1980s, the Environmental Protection Agency estimated dangerous chemicals were leaking out of at least 16,000 landfills throughout the countryside. The management of the toxic wastes produced by a progressive technological society has become yet another environmental issue demanding immediate attention.

Toxic waste has become a national problem in this country. It is an issue which has emerged through a confusing web of scientific, legal, community-based and industry-related perspectives and discoveries. Often out of ignorance and neglect, Americans have carelessly disposed of immeasurable volumes of waste materials since the end of the second World War. Manufacturers, farmers, and the general populace have poured synthetic organic chemicals, pesticides, herbicides, and industrial solvents into ponds, streams, storm drains, and poorly prepared ditches with little regard to geological limitations.

Research has revealed the potential health hazards created as a result of these neglectful activities. They range from minor discomforts (headaches, nausea) to life-threatening ailments (cancer, birth defects). The environmental damages related to this form of contamination may involve loss of vegetation, destruction of animal habitat, and the eventual elimination of certain species of wildlife within the affected geographic area. Public anxiety has stimulated widespread demand for immediate action to somehow rectify the current dismal scenario with reference to handling hazardous wastes. In most cases however, these demands seem to overlook such basic questions as:

☐ Who should engineer the clean-up?
☐ Who should pay for it?
☐ What should be done?
☐ How clean is clean?
☐ How should it be implemented?

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly referred to as Superfund, was enacted to provide for clean-up at sites where hazardous wastes had been abandoned or where previous hazardous waste disposal procedures had already contaminated the environment. Under CERCLA, the Environmental Protection Agency is responsible for collecting information about sites needing emergency or long-term clean-up. The act essentially required the EPA to generate a National Priorities List of the most critical dump sites and to develop formal regulations for implementing the Superfund program.

GENERATION OF WASTE

Efforts to estimate the amount of hazardous waste materials generated each year in this country seem to be almost futile. It is difficult to identify those corporations, small manufacturing firms, or individuals directly responsible for producing these waste materials. A portion of the difficulty stems from an array of inconsistent definitions regarding the specific wastes considered to be "hazardous."

For instance, the Resource Conservation and Recovery Act of 1976 (RCRA) defined hazardous waste as improperly managed solid waste found to cause an increase in morbidity and mortality or that poses a significant threat to human health or the environment. If you find that explanation rather vague, then you are probably not alone.

The Environmental Protection Agency adds that substances are considered hazardous if they possess the following characteristics: ignitability, corrosivity, reactivity, and toxicity. EPA further includes some, but not all, carcinogens on its list. The EPA feels the testing procedures akin to carcinogenesis (cause-effect relationship between the presence of a certain material and the development of a tumor in the body) are still somewhat unreliable. Unlike the description provided in RCRA, the EPA holds that hazardous wastes occur in any physical form—solids, liquids, semi-solids, or gases. On the other hand, the EPA definition does not include releases to sewage-treatment plants, treatment in tanks possessing permits under the Clean Water Act, or wastes beneficially used or recycled at the factories where they are generated.

A series of studies conducted by both the Environmental Protection Agency and the Office of Technology Assessment provided estimates of the amounts of hazardous waste generated annually. Their figures ranged from 41 million tons up to 264 million tons! This astonishing difference can be attributed to dissimilarities in the types of wastes included in their analysis and the sources of information surveyed. Regardless of any discrepancy among these reports, even the most conservative estimates indicate the amount of hazardous waste material generated in this country each year is staggering.

The process of identifying those establishments generating dangerous substances in the course of their production/manufacturing activities is even more difficult. Pursuant to a survey conducted by the EPA, some 70,000 firms reported they were possible generators or handlers of hazardous materials. The petrochemical companies and metal-related industries seem to account for a majority of these wastes. However, even the supposedly "clean" industries are contributing to the problem.

Recent studies indicate toxic chemicals from semiconductor plants in California's Silicon Valley region are seeping into wells and aquifers serving over 1.3 million area residents. These companies use arsenic, phosphorous, and boron to improve the conductivity of silicon crystals. Subsequent solutions of nitric and sulfuric acids are used for etching the prepared chips. Other industries which may require further investigation include some less visible establishments such as: printing shops, gas stations, dry cleaners, printed circuit board shops, textile industries, paint and ink manufacturers, and leather companies. The key point is that highly industrialized societies produce these substances and there is always going to be some residual demanding additional treatment. See Figure 10.7.

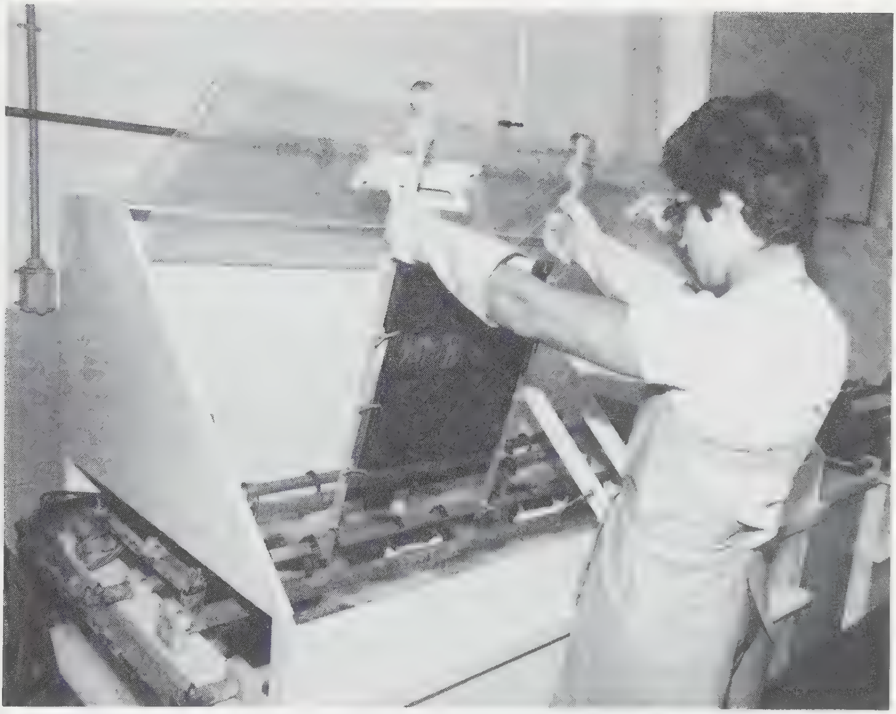


Figure 10.7 This employee works in a small shop that specializes in printed circuit board fabrication. He is shown executing the plating operation for a printed circuit board. This step takes place after the board is drilled. The plating process involves dipping the board into a series of predetermined chemical baths that ultimately plate the image needed for the specific application required by the client. This company maintains its own sophisticated water treatment plant to insure that none of these toxic chemicals are allowed to contaminate the city's water supply. (Silicon Valley Printed Circuits, Inc.)

TREATMENT, STORAGE, AND DISPOSAL TECHNIQUES

Guidelines provided by the Resource Conservation and Recovery Act (RCRA) indicate hazardous wastes may be managed by some form of treatment, storage, or disposal process. In some instances, waste materials may go through all three stages. It is also possible for a single process, such as surface impoundment, to be used for all three purposes.

Facilities that treat, store, or dispose of hazardous waste are required by law (RCRA) to obtain operating permits from the Environmental Protection Agency. These permits require periodic monitoring, record keeping, personnel training, emergency planning, and plant closure procedures. Specific design and operating procedures such as approved double liners/restraining walls for landfills are also recognized as components of more recent permits issued by the EPA.

Land disposal remains America's dominant method of managing toxic wastes. Secured landfills, industrial lagoons, and deep-well injection systems each relies on a time-worn trust in the resilient nature of soil. According to recent EPA reports, 57 percent of America's toxic wastes are injected into deep wells, and another 38 percent are kept in industrial lagoons and surface storage tanks. Other less widely used management techniques include incineration, waste recycling, and the use of genetically engineered bacteria to destroy these substances thus neutralizing their toxic effects on the environment.

A great deal of attention has been directed toward the need to limit the types of substances deposited in landfills, and the increased use of protective measures such as more comprehensive monitoring and more effective containment liners. Nearly one-third of the sites identified on the EPA's National Priorities List developed for Superfund were surface impoundments. Many of these establishments were found to be negligent in their use of monitoring wells to insure that nearby aquifers used for drinking water had not been contaminated.

Underground injection wells are often used to dispose of liquid wastes including acid/alkaline solutions, solutions containing metals, and solvents. These wastes are pumped into underground strata where they are assumed to be contained by impermeable rocks. The technology of underground injection has been used extensively in the oil and gas industry, but its viability on the toxic waste management agenda remains questionable.

Some waste management experts believe incineration of toxic wastes could spell some form of relief and substantially reduce the amount of dangerous substances going into landfills. Modern technology has introduced incinerators designed to destroy 99.9 percent of the organic waste material they handle. Refer to Figure 10.8. Materials which escape up the flue are then scrubbed out of the flue gas with auxiliary equipment. Needless to say, this is an expensive treatment/disposal process. Moreover, communities near incinerators have objected to them due to their anxieties over potential emissions from the stacks. Ocean incineration has been proposed but has not yet been implemented on a wide scale as a solution to the treatment and disposal dilemma.

Perhaps the best disposal solution for hazardous waste would be to recycle it into other uses or to recover valuable materials from the waste. Although this is not yet possible in all situations, some waste solvents used in the electronics industry have been shown to contain compounds of sufficient quality to be used again as virgin materials in other industrial settings. The EPA estimates a small but still measurable percentage of industrial wastes could be reused in this manner. It has encouraged the establishment of waste clearinghouses to implement this treatment strategy.

HAZARDOUS WASTE CLEANUP

A truism is that prevention is usually cheaper than clean-up. In the case of hazardous wastes however, it is obvious the situation has gotten out of hand to the point of crisis management in many areas of the country. Unfortunate-

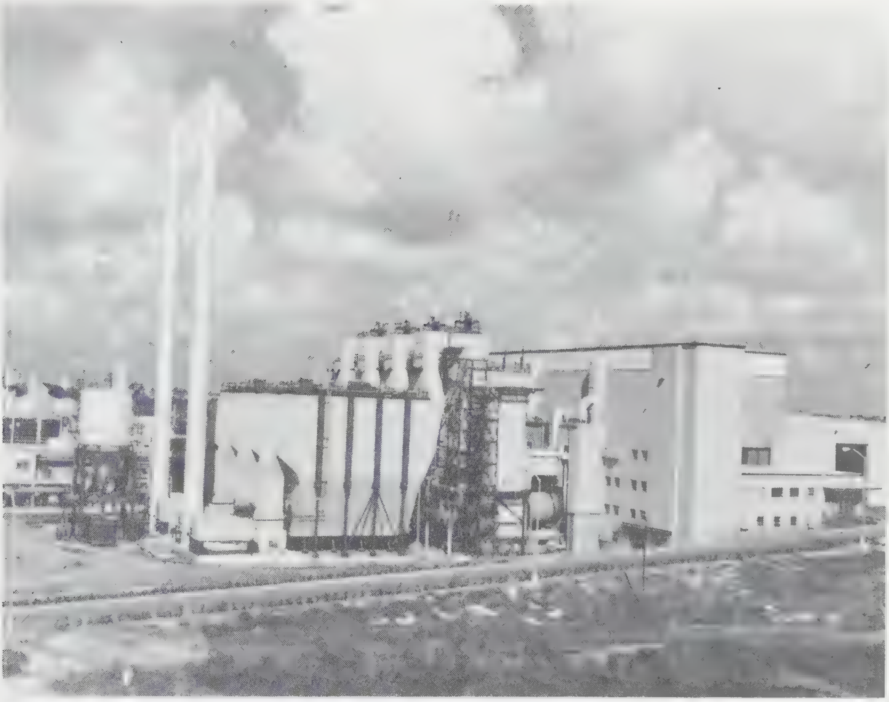


Figure 10.8 The McKay Bay Refuse-to-Energy Facility is a 1,000-ton-per-day combustion incinerator for disposal of the City of Tampa's municipal refuse. It is the state of the art successor to an incinerator which was owned and operated by the City of Tampa from 1967 to 1979. The original plant was closed down with the advent of new, strict environmental regulations. Waste Management, Inc. was awarded a full service contract by the City of Tampa in 1982 to design, build and operate a refuse-to-energy facility on the site of the original incinerator. The plant is capable of producing for sale in excess of 450 kilowatt hours of electricity per ton of refuse processed after satisfying in-plant power needs. Power is sold to Tampa Electric Company and is sufficient to satisfy the needs of approximately 10,000 homes. (Waste Management, Inc.)

ly, cleaning up the mess after the fact is easier said than done. Regardless of the clean-up procedures selected, the work is slow, complex, and costly. A "quick fix" is next to impossible.

Although the Comprehensive Environmental Response, Compensation and Liability Act (Superfund) provides funding for cleaning up the more critical hazardous waste sites, it does not provide standards for determining the degree of clean-up required. This oft-referenced "how-clean-is-clean" issue is at the core of one of the most pressing problems confronting the Superfund program. Unlike earlier federal environmental legislation, Superfund does not include standards for clean-up actions at hazardous waste sites. Some citizens would like to see this legislation modified.

Nevertheless, the EPA has difficulty determining standard levels of clean-up at this point since its experience in developing remedies for hazardous waste sites is limited. It has also become an accepted fact that each site has unique characteristics which merit individual attention. The agency has also acknowledged circumstances frequently occur wherein there are no clearly applicable standards for determining "acceptable" levels of hazardous substances in soil and other media. Developing standards for the literally hundreds of substances encountered in clean-up activities could ultimately deter the progress of the procedures presently being used.

Two types of clean-up actions are classified with the Superfund financing program — emergency actions and long-term clean-up. Dangers of fire, explosion, or acute physical effects from direct contact are typically considered as candidates for possible emergency action. Longer-term clean-up activities move more slowly and commonly entail: waste removal, treatment or containment; data collection via testing; feasibility studies; and detailed design of remedial measures.

The clean-up of the massive quantities of hazardous materials across the United States will require leadership, initiative, imagination, diligence, and patience from all segments of society. Several studies illustrate the prospect of speeding up the clean-up process which has been forecast to continue into the next century.

☐ New Jersey established an aggressive Spill Compensation and a Hazardous Discharge Fund to help pay for clean-up.

☐ California initiated an aggressive program to phase out land disposal of cyanides, strong acids, PCB liquids, and all halogenated organic substances.

☐ The Florida Department of Environmental Regulation is laying the groundwork for an in-state system of hazardous waste management.

☐ Major firms including Dow, Kodak, Dupont, and 3M are recycling and incinerating their own dangerous waste materials.

Financial and manpower constraints make it impossible for the federal government to do it all! The hazardous waste problem is generated chiefly by the private sector which provides jobs and revenue for local governments and communities. Government sponsored scientific research projects seem to be moving in the right direction toward a clearer definition of the problem as well as proposed regulatory and technical solutions. The hazardous waste problem is not amenable to a "quick fix," but it is an environmental issue that can be handled through effective cooperation among citizens, industries and government agencies in our society.

SUMMARY

Environmentalism has surfaced in this country, and around the world, as an information-based perspective on the intelligent use of technology to prevent adverse effects on the environment. The modern environmentalist is no longer perceived as an anti-establishment radical in our society. There are several key environmental issues that require dedicated, international cooperation during the upcoming decades.

This chapter focused on problems associated with the atmospheric buildup of carbon dioxide, jurisdiction of common spaces, air quality standards, the consequences of tropical forest destruction, and the management of hazardous materials. Each of these situations may seem dismal at present, but none of them is totally insoluble. Progress can be made in all areas to safeguard environmental quality for the generations to follow. Cooperation between the public and private sectors in all nations is necessary to get the momentum underway.

DISCUSSION QUESTIONS

1. Describe what the term "environmentalism" means in today's society. How does your personal opinion concerning environmental issues compare to this description?
2. Identify and discuss some examples of successful environmental policies that have emerged as a result of "grass roots movements" during the past five years.
3. Develop a future scenario that depicts at least two prospects for the fate of Antarctica in the world community.
4. With reference to at least three contemporary environmental issues, describe what is meant by the general cliche—"Prevention is usually cheaper than the cure."
5. Explain what is meant by the "greenhouse effect." Discuss the possible causes and consequences of the concept labeled "global warming."
6. How would you respond if you discovered that your state planned to establish a hazardous waste dump on a vacant property near your home? What questions would you ask? What safeguards would you expect?

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Chapter 11

INTERNATIONAL DEFENSE PROFILE

DATELINE

Omaha, Nebraska

Although the future of the controversial MX missile (''missile experimental'') is still somewhat ambiguous, it has been moved from the drawing board and testing pad to operational status. Strategic Air Command officials report that the first four MX missiles have been activated and stand alert for launch at the Warren Air Force Base in Wyoming. For the first time ever, the land-based leg of the United States' nuclear triad contains a missile that can boost 10 warheads at once toward the Soviet Union. By comparison, the older, now obsolete Minuteman missiles can carry no more than 3 warheads into a launch mode.

These four MX missiles are reportedly among the first group of 10 that are scheduled for activation in the near future to meet what the Air Force refers to as ''Initial Operational Capability'' for the new weapon. The MX missile has been labeled the ''Peacekeeper'' by several current U.S. government officials. Prior to the end of the 1980s, this first batch of 10 is scheduled to be followed by 40 more of the gigantic rockets. They are being installed in existing Minuteman silos. Congressional members remain reluctant to authorize a second batch of 50 unless the Pentagon is able to devise a more acceptable plan for basing the missile to improve its survivability . . . .

INTRODUCTION

First and foremost among the examples usually cited to illustrate the ill-effects of technological advancement is the threat of nuclear annihilation. Tucked away in top secret laboratories around the world, military scientists and defense specialists continue their search for more effective weapons. Technologists and engineers routinely sign contracts giving them the directive to design and develop a more strategic defense arsenal. We, as laypersons, are becoming conditioned to the reality that the basic nature of defense-related topics between the United States and the Soviet Union remains somewhat uncertain. The two superpowers appear to be ready to negotiate but remain fiercely competitive.

When the topic of military superiority is mentioned these days, a host of new-fashioned technologies come to mind. In fact, it is a commonly held presumption that a nation's technological edge goes hand in hand with its international militaristic stature. In other words, more technology spells greater military prowess. More than fifteen years ago, the United States and the Soviet Union signed a treaty which says that each country guarantees to keep its citizens *undefended* against a nuclear attack by the opposing side. Known as the Anti-Ballistic Missile (ABM) treaty, this agreement was authored by diplomatic officials who concluded that if both superpowers leave themselves undefended, neither one will attempt to gain victory over the other. Specifically, the Soviets know that when they launch a missile attack against us, our own missiles will destroy their homeland in reprisal. Alternately, the United States armed forces realize that if we attack the Soviet Union, their missiles will leave our countryside in ruins. This knowledge supposedly deters both nations from starting a nuclear war.

The individuals who devised this particular strategy furnished us with the acronym "MAD" which stands for Mutual Assured Destruction. In other words, it assures the destruction of both nations if either one makes the mistake of attempting to launch a "first strike." The MAD doctrine presents a very real moral dilemma for today's political leaders and military commanders. MAD is a grossly inhumane policy in that it leaves the American people vulnerable to incineration by Soviet nuclear weapons and offers the retaliatory devastation of the Soviet population as the only deterrent.

In an attempt to reduce our reliance on the specter of retaliation, the United States federal government fostered a new strategic vision. In his now famous "Star Wars" speech delivered in early 1983, President Reagan commissioned scientists and technologists to devise a means of intercepting and destroying the attacking missiles and their warheads in mid-flight. He introduced the notion of a "peace shield" to be set in place between the United States and its enemies to protect civilians from the deadly weapons of our adversary. Out of this address was borne the Strategic Defense Initiative (SDI). The SDI has, for the most part, been described as a comprehensive research program with the ultimate potential to render nuclear weapons obsolete in our lifetime. Along the way, the SDI program has witnessed a number of dramatic technological breakthroughs toward the development of a multi-layered, multi-technology approach to ballistic missile defense. Somewhere on the impressive list of successful defense mechanisms these researchers are in the process of designing you will find: kinetic kill weapons, long and short wavelength lasers, electromagnetic rail guns, X-ray lasers, microwave weapons, neutral particle beams, free electron lasers, and rubber mirrors. This is by no means an exhaustive listing, but this small sampling should give you some idea of where we are heading with regard to our defense program.

For many of us, the sophistication level of the technologies associated with military leadership is beyond our wildest imagination. The international defense profile seems to change a little each time we hear about another new sensor device, a robotic-controlled suit of armor, or another promising missile-basing scheme. As you review the topics introduced in this chapter, you may begin to understand and grasp the reason many historians point to war as a primary trigger for technological change. For centuries, mankind's instinctive response to any sort of threat to survival has been enmeshed in a technology of some sort. Prior to the emergence of our contemporary nuclear age, every new weapon prompted a defense that could counter it. Even when civilian populations became the target, effective defensive technologies appeared on the scene. The bombs that brought an end to World War II changed that chain of development. The instant annihilation of Hiroshima shifted the balance between offense and defense to the point where there was no longer an effective maneuver to protect the civilian population in war.

While military technology may actually be similar to other technology-laden disciplines in several ways, its ultimate objective represents a clear point of departure. Military technologists are driven by a competitive and often nationalistic spirit. They certainly struggle with ethical and moral issues as they improvise more lethal weapons in the laboratory. These same emotions are said to stimulate performance among the biotechnologists who are paving the future of genetic engineering, medical technologists who study alternative procreation methods and manufacturing engineers who are involved in the global market of technological expertise. On the other hand, military technology is unique from the standpoint that its primary goal is defined by its capacity to destroy human life.

1. Will the quest for military superiority inhibit the establishment of a cooperative relationship among the world's superpowers?
2. From an economic perspective, how does the United States' military budget influence employment patterns and affect industrial competitiveness?
3. Is the Strategic Defense Initiative feasible in the foreseeable future? Regarding the goals of this defense program, why has it become such a controversial issue over the past few years?
4. What are the environmental consequences resulting from use of nuclear weapons?
5. If contemporary government leaders are at all interested in the sustenance of human life, how should they attempt to redefine their national security objectives?

KEY CONCEPTS

The field of military technology and defense strategy is full of technical terms and confusing acronyms. This chapter will examine a small portion of them in its discussion of the current international defense profile. As you read through the various segments, stay alert for the following concepts.

Nuclear Winter
Mutual Assured Destruction (MAD)
Applied Deterrence
Biological Warfare (BW)
First Strike
First Use
Decoys & Chaff
Neutral-Particle Beam Device
Railguns
Airborne Optical Adjunct
Black Budget
Chemical Lasers
Excimer Lasers
X-ray Lasers
Strategic Defense Initiative
MX Missile
Counter-Force Targeting
Counter-Value Targeting
MIRV
Deterrence
Second Strike
ERIS
MIRACL
"C^3I"
Rubber Mirrors
Electromagnetic Guns

THE QUEST FOR MILITARY SUPERIORITY

National security is a concept which has always had its fair share of respect among the general populace. It is commonly used to justify the maintenance of armed forces, the development and/or procurement of new weapons systems, and the manufacture of armaments. Furthermore, a significant percentage of the gross national products of several nations is allocated toward the preservation of national security. See Figure 11.1. Over the past five decades, the national security objective has become inextricably linked with the quest for military superiority.

The timeless concept of national security is based on the assumption that the principal threat to one's security comes from other nations around the globe. The idea that countries everywhere should be prepared to defend themselves at all times from an external invasion is relatively recent. Prior to World War II, countries mobilized their troops in times of war instead of maintaining large, permanent military installations. Since that time, global military expenditures have grown enormously and the number of persons who are in one way or another employed in a defense-related job has increased significantly.

The principal stimulus behind global militarization is found in the ideological conflict between the Soviet Union with its socialist allies, and the United States in alliance with the world's industrial democracies. In recent years, the further alignment of Third World countries with these superpowers suggests the militarization process is independent of economic status or the level of technological development.

Since the mid-1940s, the dominant influence in world politics has been entrenched in a bipolar rivalry between the Soviets and the Americans. One of the hallmarks of this geopolitical struggle has been the nuclear arms race. Gradually, but surely, the pace of this race increased and its dynamics have become ever more frightening. Some political observers are convinced international tension would be reduced considerably if the arms race could be curtailed and reversed. Proponents of the arms race conjecture that it represents

MILITARY EXPENDITURES AS A SHARE OF GNP FOR SELECTED NATIONS, 1984

Country	Share (percentage)
Industrial countries	
Japan	1.0
Canada	2.1
West Germany	3.3
United Kingdom	5.4
United States	6.9
Soviet Union	14.0
Middle East	
Egypt	8.3
Syria	13.0
Jordan	14.9
Saudi Arabia	24.0
Israel	29.0
Asia	
Sri Lanka	1.5
India	3.5
Pakistan	5.4
China	8.0

Country	Share (percentage)
Africa	
Nigeria	2.5
South Africa	4.3
Ethiopia	11.0
Libya	17.5
Latin America	
Mexico	0.6
Brazil	0.7
Venezuela	1.3
El Salvador	4.0
Chile	4.5
Nicaragua	10.2

Figure 11.1 Military expenditures as share of GNP for selected countries. (United States Arms Control & Disarmament Agency: Stockholm International Peace Research Institute Yearbook)

a logical surrogate for an all-out war in that it constantly tests each contender's level of national will, technical genius, and strength.

The cost of the arms race to the superpowers is placing a heavy drain on their treasuries and eating away at their respective positions in the international economic hierarchy. This long and drawn-out battle to win a race that may not by "winnable" may lead to a realignment of the leading industrial countries. One of the reasons Japan has been able to come forth as an economic leader may be related to its negligible level of military expenditures. In the mid 1980s, it spent just under 1 percent of its GNP for military purposes while benefitting from United States defense of its geographic region.

Conversely, the United States national debt doubled in the first five years of the 1980s decade. Much of that increase was due to the real growth in military expenditures since the late 1970s. For instance, weapons research expenses continually exceed the United States government's combined investments in developing new energy technologies, improving human health, raising agricultural productivity, and abating pollution. Disproportionate military expenditures may be weakening the United States' economic base and gradually diminishing its capacity to act as a world leader.

UNDERLYING CONCEPTS TO NUCLEAR ARMS POLICY

There is little doubt the international defense profile has undergone a significant measure of change due to the intensification of the arms race. Both the United States and the Soviet Union feel threatened. Each nation continues to invest heavily in new weapons systems while it simultaneously explores more effective avenues for arms-control negotiations. The idea of an arms race encapsulates (contains) the notion that each nation is trying to gain superiority in military prowess. Beginning sometime in the late 19th century, the application of technology in the arms race was recognized for its capacity to provide both quantitative and qualitative advantages for its possessor.

Contemporary nuclear weapons are couched in technological sophistication. They may be used in a number of different ways. Several distinctions which illustrate their utility may be explained by the following concepts:

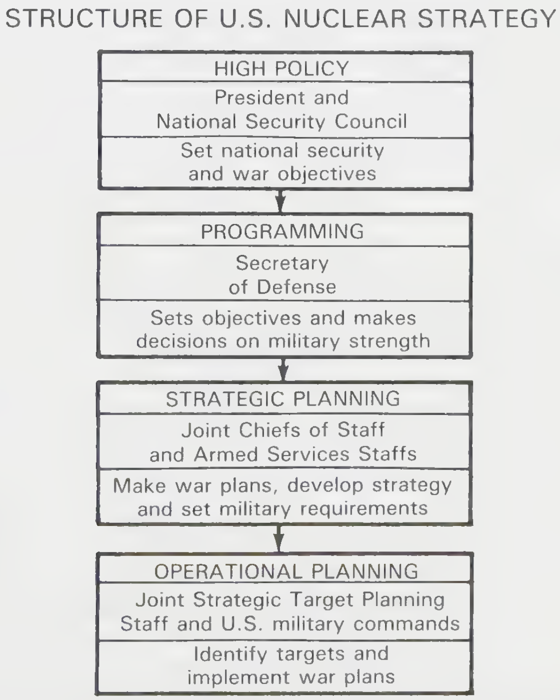
1. **First strike** = a disarming attack on the enemy. Generally connotes a nuclear attack so powerful as to leave one's opponent with forces insufficient to inflict substantial damage on the attacker. In contrast, the term **first use** generally refers to the initial use of nuclear weapons in a military conflict with much more limited objectives (destruction of an enemy tank).
2. **Second strike** = a procedure following a nuclear attack where weapons are used in retaliation against the enemy. This concept implies the ability to survive a first strike.
3. **Counter-force targeting** = a strategy where weapons are aimed at the military forces of the other side, particularly at strategic or theatre nuclear forces.
4. **Counter-value targeting** = a program which aims its weapons at "softer" targets (urban centers, industrial, and economic enterprises).

Counter-force targeting requires very accurate missiles in order to be successful against hardened missile silos and military command posts or control headquarters. As mentioned earlier, when both sides have the ability to absorb a first strike and deliver a retaliatory second strike capable of inflicting an unacceptable level of damage, a situation of mutual assured destruction (MAD) is presumed to exist. This retaliatory attack is generally held to be aimed at counter-value targets such as civilian population centers. Since there is little point in targeting empty missile silos (they would be empty after an offensive first strike attack had been launched), a counter-value targeting strategy is likely to have the greatest deterrent effect.

In contemporary society, the concept of deterrence has come to mean nuclear deterrence. By comparison in NATO (North Atlantic Treaty Organization) doctrine, there is an assumption that deterrence is invoked across the whole spectrum of military forces. From conventional forces through battlefield and theatre nuclear weapons to strategic devices, the concept of **applied deterrence** necessitates a wide range of weapons to prepare for different scenarios. Applied deterrence is linked with the strategic philosophy of **flexible response** and requires the ability to destroy military as well as urban-industrial targets. The combination of these two precepts (applied deterrence plus flexible response) seems to imply that all nations must possess many different types of weapons and also be ready at all times to fend off any enemy nation's assault. NATO's perception of deterrence differs fundamentally from the concept of **pure nuclear deterrence** embodied in the idea of massive retaliation or MAD.

UNITED STATES NUCLEAR STRATEGY

Nuclear strategy does not consist of concepts or even policy statements. In reality, nuclear strategy entails a series of concrete decisions regarding war plans, budgets, forces and deployments. On a practical level, nuclear strategy is a government process wherein decision making takes place on several levels. Figure 11.2 illustrates this hierarchy and implies various levels of responsibility. This multi-level approach to strategy development took shape early in the nuclear age when the Truman administration inherited and then reluctantly accepted nuclear weapons as the mainstay of United States defense.


STRUCTURE OF U.S. NUCLEAR STRATEGY
HIGH POLICY
President and National Security Council
Set national security and war objectives
PROGRAMMING
Secretary of Defense
Sets objectives and makes decisions on military strength
STRATEGIC PLANNING
Joint Chiefs of Staff and Armed Services Staffs
Make war plans, develop strategy and set military requirements
OPERATIONAL PLANNING
Joint Strategic Target Planning Staff and U.S. military commands
Identify targets and implement war plans

Each of the four levels of strategic planning can head in a direction different from the others, as each responds not just to guidance from levels above, but to separate organizational needs and restraints. These bureaucratic structures help account for contradictions and divergences that emerge between the president's stated policy, the Defense Department's force posture, the plans of the Joint Chiefs of Staff, and the final implementation of plans by the Joint Strategic Target Planning Staff and the military commands.

Figure 11.2 Structure of United States nuclear strategy from the standpoint of strategic planning levels in our government.

In the years immediately following World War II, the United States enjoyed a monopoly of nuclear weapons. Air Force officials felt air power could be most effectively used to attack the enemy's war-supporting industrial base and communications system, and undermine civilian morale at the same time. By the close of the 1940s, this policy was being challenged on several fronts. Essentially, the morality of strategic bombing was challenged on the grounds that the innocent civilian residents would be its inevitable victims.

At the same time, the Soviet Union had just exploded its first atomic bomb. This event caused the U.S. Joint Chiefs of Staff to recommend and later adopt a set of targeting categories for United States nuclear weaponry. Top priority was given to the destruction of known targets directly affecting the Soviet capability to deploy their atomic weapons. Second priority was afforded to what were called retardation targets or those transportation links that, if destroyed, would inhibit the western movement of Soviet troops across the European continent. The third priority was assigned to a set of specific urban industrial facilities including Soviet liquid fuel, electric power, and atomic energy industries.

In identifying Soviet nuclear capability as the highest priority target, the Joint Chiefs effectively chose to prepare the United States' nuclear offense for a pre-emptive attack on the enemy's offensive forces. For several years, United States nuclear policy was clearly based on sustaining the resources to launch a pre-emptive first strike against the Soviets, if we became certain they were preparing to attack us. During the 1950s, the Eisenhower administration approved a national security policy under which America would respond to large-scale aggression with massive nuclear retaliation. When it became evident the Soviet Union might possess the power to initiate its own pre-emptive attack on the U.S.A., this policy of massive retaliation was viewed in a different light.

Through the NATO military alliance, the United States has been linked to Western Europe since the late 1940s. The policy assumption that Soviet aggression in Europe would result in massive retaliation was seriously examined by observers who wondered whether the United States would actually risk nuclear annihilation in the defense of its European allies. It also became apparent the use of nuclear weapons in Europe would be tremendously destructive, particularly to the Federal Republic of Germany.

When Robert McNamara became Secretary of Defense in the early 1960s, he announced his intent to bring some order into a nuclear policy which had gotten out of control. His first priority was to move away from the pre-emptive, all-out approach to nuclear strategy. During his tenure, a strategy was proposed to deter aggression by maintaining forces adequate to counter an attack at whatever level the aggressor chose to fight. The primary elements of this policy are: conventional and nuclear deterrence, forward defense (an arsenal strong enough to defend the United States against a first strike and retaliate against the aggressor), and flexible response involving the will and ability to escalate as necessary. The flexible response concept allows for the first-use of nuclear weapons with the expectation NATO would not be able to fight a prolonged conventional war. By the end of his term, McNamara's most lasting contribution to nuclear strategy was the long-term objective of assured destruction of Soviet society. This became an approach to defining what strategic forces would be adequate to deter the Soviets from launching a first strike in a crisis. He believed this goal required enough warheads in a secure second strike force to destroy at least one-half of Soviet industrial capacity and one-fifth to one-fourth of the Soviet population.

While deterrence emerged as a central concept in U.S. nuclear policy by the 1960s, pre-emptive (first) counter-force targeting has remained a permanent option in this nation's strategic planning efforts. U.S. nuclear strategy has been heavily influenced by its lasting commitment to defend Western Europe. It seems over-reliance on United States nuclear weapons to either deter or fight a war in Europe has created serious political, as well as military, problems for all parties. Efforts to limit the size of the U.S. nuclear arsenal have repeatedly been dispelled by the objective that a first strike must not be permitted.

All military strategies become obsolete as technology changes. Every United States president since Eisenhower has been forced to confront the reality that nuclear war, even with U.S. pre-emption (first option or first action), will most certainly be tantamount (equivalent) to national suicide. Contemporary policy makers are discussing arms reduction strategies in an attempt to further advance the goals initially established during the Strategic Arms Limitation Talks (SALT) conducted in the 1970s.

SOVIET NUCLEAR POLICY

Within a decade after World War II ended, Soviet leaders had grown quite fearful of and worried by the nuclear superiority of the United States. Eisenhower's massive retaliation policy and the threat of a United States first strike against the USSR did much to shape Soviet assumptions about the nature of another world war. By the mid-1950s, Soviet military doctrine held that a world war would most certainly be nuclear and would entail massive strikes on Russian soil. It envisioned a fight to the finish between the socialist and capitalist systems wherein defeat would be synonymous with extinction.

Soviet leaders developed a strategy of nuclear arms escalation predicated (based) on nuclear pre-emption. Subsequently, a policy emerged which called for the possession of sufficient nuclear forces to survive a United States first strike and retaliate with strength. This does not mean the Soviet Union will wait for incoming U.S. or NATO missiles to arrive. As soon as there is indisputable evidence an attack has been launched, Soviet strategy calls for a massive nuclear response designed to totally disrupt the adversary's onslaught. At one level, this policy can be interpreted to mean "Launch on Warning" (LOW). Essentially, Soviet military leaders reject the defensive strategy based on the concept of absorbing the enemy's first nuclear blast.

By the late 1960s, Soviet targeting policy emphasized the readiness to launch a blitzkrieg using conventional arms against NATO's main forces. Highest priority is given to the West's nuclear retaliatory force in an effort to limit damage to its own homeland. Second-level priorities include other major military bases, command centers, economic establishments, and all other targets which support the enemy's capacity to stay involved in a war.

The Soviets recognized the danger that the United States would assuredly launch a full-scale nuclear strike against Russia if NATO forces were facing defeat in Europe. Deterrence appeared to be the only defense against such an attack. From the Soviet vantage point, deterrence meant the North American continent would be severely damaged via a massive nuclear retaliation. In preparation for any sort of aggression, the Soviets hardened their intercontinental ballistic missile (ICBM) silos against nuclear blast and deployed new Delta ballistic-missile submarines. The simultaneous growth in the size and diversity of the United States arsenal soon revealed that a pre-emptive Soviet strike would not be able to disable a sufficient number of U.S. weapons to limit damage to the Russian countryside. They have since avoided the suggestion of first use which might precipitate a United States decision to launch a strategic first strike against them. Soviet nuclear strategy seems to have current forces braced for NATO and the United States to strike first.

From this perspective, it is logical to deduce how one's technology might be said to determine its strategies and policies with regard to national security. Since the second World War, the United States has led in the technological arms race. Despite periodic reports the Soviet Union is pulling ahead in the arms competition, a majority of the commentators reviewed indicate it lags behind the United States in sophisticated military technology.

Constructing effective advanced technology defense systems depends on progress in several complementary technologies including: sensing, tracking, pointing, optics, materials, computer hardware, and software program development. The Soviets have had difficulty with several of these technologies. Computer hardware and microelectronics seem to be the most serious weakness in their current strategic defense efforts. The Soviet Union lags behind the United States across a broad spectrum of militarily significant basic technologies. See Figure 11.3. Although the Soviets appear to be in enthusiastic pursuit of advanced technologies germane (related) to strategic defense research, this "techno-scorecard" does not seem likely to change drastically in the near future. The extent to which this technical lag situation may influence the profile and content of future military negotiations remains to be seen. To date, both superpowers seem willing to admit that anyone who starts a nuclear war is making the decision, for all humanity, to commit suicide.

THE STRATEGIC DEFENSE INITIATIVE: A.K.A. "STAR WARS"

Midway through his first term of office, President Reagan delivered a speech to the American people that represented a radical shift in United States defense policy. The sentiment of his national address offered the hope of a world made safe from the threat of intercontinental ballistic missiles. Mr. Reagan pointed toward technological expertise and scientific genius as the tools which might

THE SOVIET LAG IN BASIC TECHNOLOGIES

Basic Technologies	U.S. superior	U.S./U.S.S.R. equal	U.S.S.R. superior
Aerodynamics/fluid dynamics	X		
Computers and software	←X		
Conventional warheads (including all chemical explosives)		X	
Directed energy (laser)		X	
Electro-optical sensor (including infrared)	X		
Guidance and navigation	X		
Life sciences (human factors/ biotechnology)	X		
Materials (lightweight, high-strength, high-temperature)	X→		
Micro-electronic materials and integrated circuit manufacturing	X		
Nuclear warheads		X	
Optics		X	
Power sources (mobile) (includes energy storage)		X	
Production manufacturing (includes automated control)	X		
Propulsion (aerospace and ground vehicles)	X→		
Radar sensor	X→		
Robotics and machine intelligence	X		
Signal processing	X		
Signature reduction	X		
Submarine detection	X→		
Telecommunications (includes fiber optics)	X		

This list identifies 20 technologies selected by the Department of Defense to provide a base for comparing overall U.S. and U.S.S.R. basic technology. These technologies have the potential to significantly influence the military profile of the world in the next 10 to 20 years. Arrows denote the relative technology level is shifting in the direction indicated.

Figure 11.3 Chart which lists basic military technologies where the Soviet Union lags behind the United States. (U.S. Dept. of Defense)

make nuclear weapons obsolete. He explained the need to strengthen deterrence through effective defense systems rather than through the continued threat of retaliation. This obvious shift from offense to defense represented the most far-reaching change in nuclear strategy since the first atomic bomb was dropped on Hiroshima.

The gradual proliferation of highly sophisticated and extremely powerful nuclear weapons since that time led us to the current MAD condition. Nuclear weapons are too forceful to use and too powerful to defend against. Nuclear weapons are, in actuality, self-deterring. For the past several decades, the two superpowers have managed to keep peace on the planet by keeping themselves vulnerable to one another. Although neither nation feels comfortable with its vulnerability, previous attempts to establish defensive protection against nuclear delivery systems have only spawned new types of military technologies.

During the 1950s and '60s, the global leaders threatened each other with bombers and defended themselves with anti-aircraft installations. These air-based systems served to stimulate the development of intercontinental ballistic missiles (ICBMs). ICBMs of the 1960s were characterized by three distinct flight phases.

During the first, or "boost" phase, the ICBM's rocket engines burned for a few minutes to thrust the warhead up into space and on its way toward its target. Once in space, the rocket engines separated and the warhead proceeded on a "ballistic" arc hundreds of miles up and thousands of miles long. This "midcourse" phase lasted about 30 minutes. In its final moments of flight, the warhead, or re-entry vehicle (RV), re-entered the earth's atmosphere over its target in what is called the "terminal" phase. Both the United States and the USSR soon developed anti-ballistic missiles (ABMs) to defend against these early-model ICBMs.

As a way of overwhelming this form of defense, both countries later developed and deployed missiles with multiple independently targetable re-entry vehicles, known as MIRVs. On top of a MIRVed ICBM rests a device which carries three or more nuclear warheads. This device is called a "post-boost vehicle" or simply a "bus." The bus has its own small rocket engine which fires repeatedly once it reaches outer space to send each warhead toward a different target. The enormous Soviet SS-18 can carry ten or more warheads—each one is capable of striking a different target. See Figure 11.4. The mighty MX missile mentioned in the DATELINE section of this chapter is a prime example of an American MIRVed missile. The scenario in which ABMs provoked MIRVs is a classic model of the offense-defense spiral. The resultant buildup of MIRVs has greatly influenced the preservation of strategic stability and the quest for arms control.

During the mid-1980s, the nuclear stockpiles of the two superpowers were roughly comparable in overall size. The United States has a slight edge in some weapons such as cruise missiles and submarine-launched ballistic missiles (SLBMs). On the other hand, the Soviets have an advantage in the key category

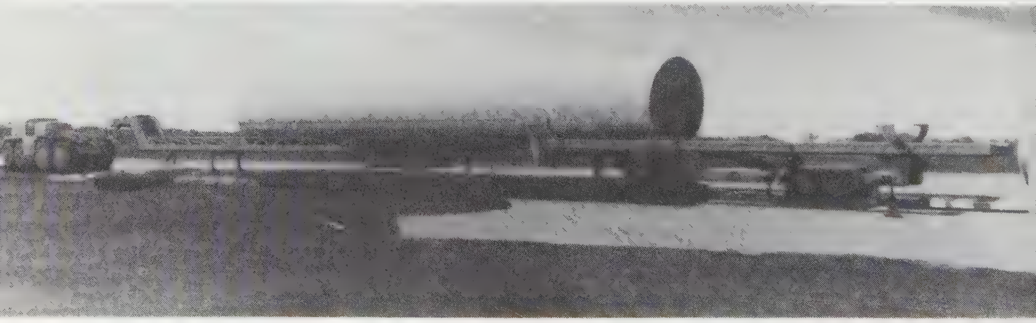


Figure 11.4 Artist's rendering of the Soviet Union's powerful SS-18 MIRVed Follow-On ICBM. (Courtesty Department of Defense)

of accurate, destructive warheads mounted on ICBMs. Approximate counts at this point indicate they have more than 6000, compared with the United States' estimated 2000 payloads. These warheads are labeled "silo-busters." They are the instruments of a hypothetical first-strike against the ICBM launchers based on the North American continent. This Soviet supremacy in ICBM warheads is a large part of President Reagan's enthusiasm for the Strategic Defense Initiative (SDI) proposed in the early 1980s. Officially, the SDI is a five-year research and development program to explore the possibilities of strategic defense so a future President and Congress can make a decision about its future deployment in the early 1990s. For most of its advocates, while research continues, the SDI is a declaration America has made a decision to base its security on a brand new strategy.

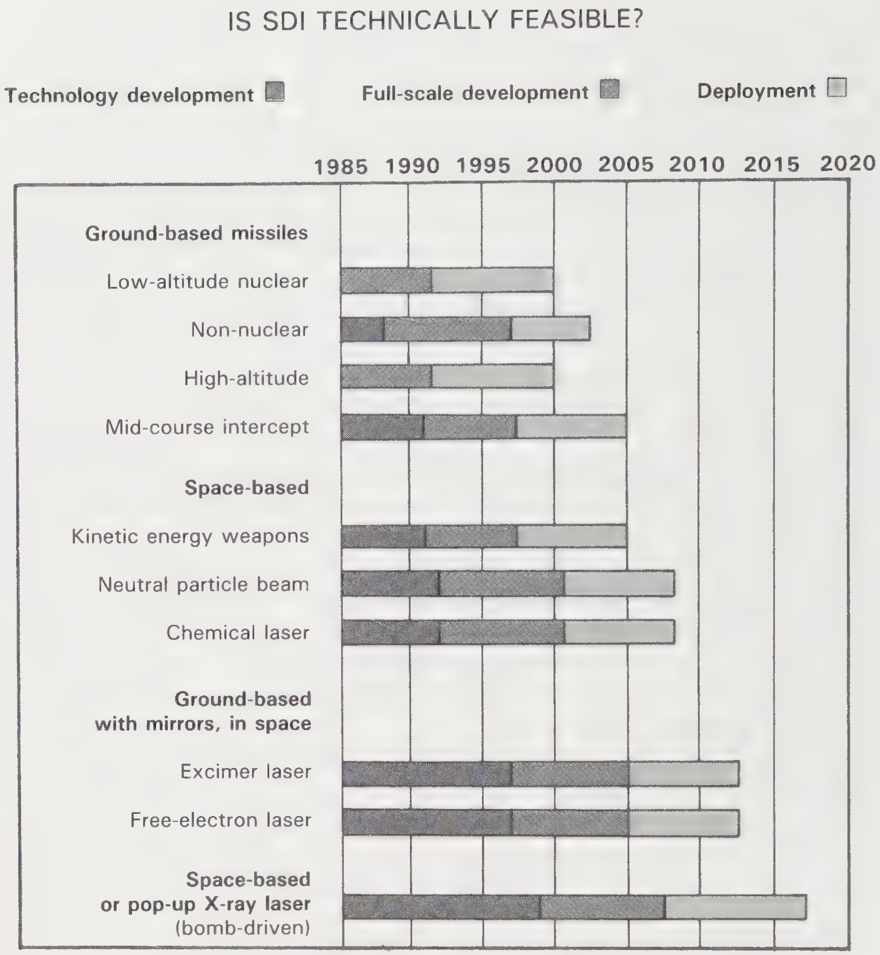
Within a year after the first public mention of an SDI program, a Strategic Defense Technology office was established with the U.S. Department of Defense. An SDI program manager was selected by the Secretary of Defense. Soon after, research and development projects were initiated in several national laboratories and private companies. The early discussions centered on the viability of a space-based defense shield to protect against incoming ICBMs. Once media representatives learned of this tactic, the SDI was dubbed the "Star Wars" approach to world peace.

Within a few short years, the SDI mission has received the lion's share of the Defense Department's budget. While numerous technological breakthroughs have been made as a result of this generous funding pattern, there are still deep concerns with regard for its technical feasibility. The chart illustrated in Figure 11.5 identifies some of the critical technologies thus far associated with the eventuality of a full-scale SDI, along with an estimated timeline for their deployment. Some of these technologies having the potential to turn SDI theory into reality are discussed in the following paragraphs.

THE CONCEPT OF STRATEGIC DEFENSE

Every proposal for a missile defense system begins with a profile of an enemy nuclear attack. The flight of contemporary ICBMs lasts roughly 30 minutes as it passes through four separate phases. As with earlier versions, the first is the "boost" phase in which the first and second stage rockets of the missile are burning. They produce intense heat and a highly visible infrared signature.

In the second, or "post-boost" phase, the bus separates from the main engines, and the multiple warheads are deployed along with any penetration aids such as decoys and chaff. Chaff consists of thin, confetti-like metal strips released in front of an opponent's radar. If mistaken for an attacking warhead, the opponent will presumably waste ammunition trying to destroy the chaff while the real warheads get through. Decoys are dummy warheads made to look like the real thing but carry no explosive power. Decoys are released along with the real warheads in a ratio of as many as 10 to 1. Once again, the opponent's defense system "reads" the decoys as real warheads and wastes time and ammunition destroying them, Figure 11.6.



This chart summarizes the estimated time scale for Strategic Defense Initiative development with the assumption that funding for "Star Wars" projects will continue as proposed.

Figure 11.5 Chart which delineates SDI technological timeline and the feasibility of its realization. (Foreign Affairs)

In the third, or "midcourse" phase, the multiple warheads travel on ballistic trajectories in a long arc over the top of the globe. They travel at a height of about 700 miles with a speed just under 20,000 miles per hour. In the "terminal" phase, the warheads re-enter the atmosphere on final approach to their targets. The penetration aids burn up at this point.

The SDI program is committed to the development of technologies to enable the United States to engage missiles in all four phases of flight. The most leverage is in destroying the missiles in their boost phase since the multiple warheads and decoys have not yet been deployed. The boost phase is normally

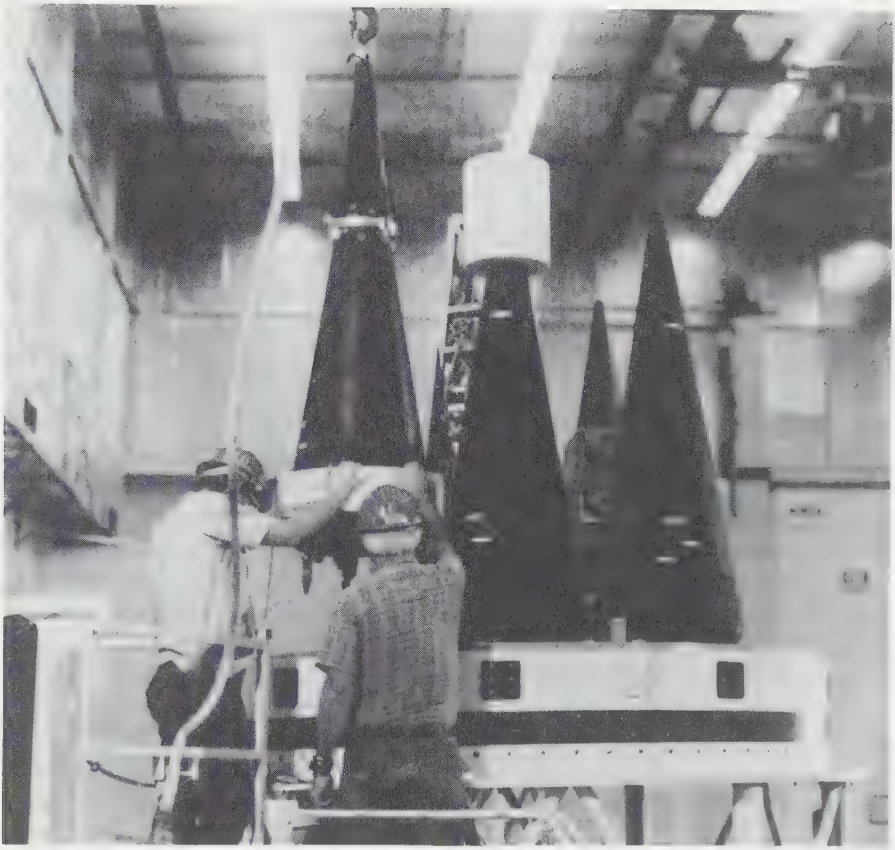


Figure 11.6 Vandenberg AFB, California. Technicians are shown here placing cones on the top of an MX Pathfinder missile's ring inside a preassembly building. "Decoys" are cone shaped objects that look just like the real thing. (Courtesy of Department of Defense)

finished in less than five minutes after the missiles are launched. After deployment, the defense system must be able to discriminate warheads from decoys in order to assure efficient targeting. Weapons designed to attack during the boost phase and midcourse must be able to see their targets. The curvature of the earth requires they be positioned up in space. They also have to be able to attack from hundreds of miles away, which means the ammunition used must reach its target in a matter of seconds.

The terminal layer of a strategic defense system must be prepared to destroy incoming warheads at as high an altitude as possible in order to shield large urban-industrial targets from the resultant nuclear blast. In order to accomplish these strategic objectives, the initial task of the SDI is to design, develop, and test weapons like lasers, particle beams, electromagnetic launchers, and a host of other mind-boggling devices.

"STAR WARS" WEAPONRY*

The actual hardware in a missile defense system has three main elements: sensors, weapons and battle management. The sensors are the eyes of the system that can detect, identify, and track the missile or warhead targets. The weapons, of course, are designed and expected to do the job of stopping the attacking missiles and warheads. The battle management part is the brain of the system. It uses computers to decide which weapons to assign to which targets and to keep abreast of the overall engagement. The acronym "SATKA" is sometimes used to describe this computer system; it is short for Surveillance, Acquisition, Tracking and Kill Assessment.

Within the SDI research and development efforts, the free electron laser and the neutral-particle beam are presently leading the pack of the new technologies. The neutral-particle beam device fires a beam of fast-moving atomic particles at the oncoming warheads. The beam shears through the warhead and scrambles its electronics so the nuclear weapon housed inside cannot explode. Neutral-particle beams would pass right through decoys while they are being absorbed by the heavier warheads. In this way, they are able to "weigh" objects in space. This ability to weigh is a crucial requirement in the defense system as a whole. The SDI team plans to test a neutral-particle beam in space in the early 1990s. They project that neutral-particle beam accelerators could feasibly be in orbit protecting Americans against Soviet missiles later on in that decade.

Another important SDI test scheduled for execution in the near future involves the **airborne optical adjunct** (AOA). This is an experimental airborne early warning surveillance sensor system. The AOA detects a Soviet warhead as it approaches our territory, tracks it, and then delivers the information to a "smart" bullet that steers itself toward the warhead and destroys it. The SDI team plans to test the system on commercially available aircraft such as the modified Boeing 767 or the McDonnell Douglas DC-8. It further predicts the AOA could be the heart of the European allies' defense against Soviet missiles.

The following list presents a brief description of several other technologies recognized as integral components of future plans for a multi-layered missile defense system. It is by no means an exhaustive portrayal of the R&D endeavors that are presently in progress around the country.

Chemical Lasers

The idea of a space-based chemical laser which could shoot down missiles in their boost phase was one of the first options to be explored by the SDI researchers. A chemical laser is a high-energy beam of concentrated light derived from a chemical reaction of the hydrogen fluoride compound. One of the largest of these is the Mid Infra Red Advanced Chemical Laser (MIRACL). It was built for the U.S. Navy to determine whether or not lasers could engage enemy missiles launched at its ships. Since MIRACL requires hundreds of tons of chemical fuel and an enormous optical system, chemical lasers of this type would be too unwieldy to deploy into a space-based battle post.

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* This section provides a cursory overview of some of the technologies being developed as part of the Strategic Defense Initiative program. For a more comprehensive visual presentation of how space-based weapons systems might be expected to work and the types of limitations they might encounter, the following videotape is highly recommended. *A NOVA/FRONTLINE SPECIAL REPORT: VISIONS OF STAR WARS* (#5008). Program originally broadcast on PBS.

Excimer Lasers

Excimer is short for "excited dimer." A dimer is a pair of linked atoms. Short wavelength beams are emitted when the bonds linking these atoms are broken. These beams are strong enough to disable an enemy missile in a few seconds. An excimer (or free electron) laser of this type would require large and cumbersome apparatus and thus would necessitate a ground-based plan for the deployment of the weapon. They are envisioned to be able to project a laser beam up through the atmosphere and out 22,000 miles in space where a geosynchronous relay mirror would deflect it back over to a second mirror in an orbit over the Soviet Union. This "battle" mirror would then direct the beam at missiles rising from their launch sites. These mirrors would have to be gigantic, (perhaps 90 feet in diameter), and almost perfect (the slightest pitting or warping could cause the laser beam to scatter).

X-ray Laser

This is sometimes referred to as "Star Wars Secret Weapon." A hydrogen bomb rests at the heart of an X-ray laser. When the bomb explodes, a fraction of its enormous power is channeled into focused beams of X-rays. Each of these X-rays can be pointed at a different Soviet booster. Despite the fact the laser self-destructs each time it is fired, it can theoretically knock out dozens of Soviet rockets instantaneously. An X-ray laser beam could be as wide as two football fields, thus requiring less precision in aiming. Top secret tests are underway in underground sites in the United States. (This testing has, in itself, become a controversial issue in recent years.) Furthermore, if an X-ray laser is perfected and built, basing them in space might require keeping something like 1400 atomic bombs in low orbits around the earth. It is probable the notion of having hydrogen bombs constantly overhead will *not* be politically acceptable. The alternative is to keep them on the ground until needed and then "pop them up" by rockets if the Soviets launch an attack. X-ray lasers only shoot in straight lines. If they are launched from the United States, they must climb very high, very quickly if they are to be able to see around the curve of the earth and catch the Soviet rockets while they are still in their boost phase.

Electromagnetic Guns

Also known simply as "railguns," this technology uses electromagnetic energy to fire small projectiles at extremely high speeds at incoming vehicles. Progress has been made in testing the "gun" which has demonstrated its ability to fire its "smart" bullets at the rate of five per half second. A space-based railgun would ultimately be deployed to seek out boosters and destroy them with direct impact during the 2nd or 3rd phase of their flight.

Rubber Mirrors

This is a mirror coated with substances to change the focus of a laser beam automatically and instantly. By sharpening a laser beam's focus, the rubber mirror can compensate for the dissipating effect the atmosphere can have on laser beams. Advancements being made in this area of materials science are critical in that they will permit heavy lasers to be stationed on the ground rather than in highly impractical orbits.

THE BUSINESS OF "STAR WARS"

The above-listed projects are just a few of the many technologies being developed as a part of the SDI program. These, along with many others, defy the imaginations of many laypersons who are being asked to make crucial budget decisions. Would you be anxious to allocate thousands of dollars to a late-midcourse exoatmospheric kinetic energy interceptor system?! Nevertheless, the SDI has become big business, spending over $4 billion in a few short years. The "Star Wars" project is well on its way to becoming the biggest single research bonanza ever. Even if the SDI proves to be technologically feasible, serious questions arise as to whether it really will strengthen deterrence at a cost we can absorb. Estimates started at $60 billion for a rudimentary system reliant on interceptor rockets. Calculations concerning the cost of a fully developed laser- or particle-beam system range between $100 billion and a staggering $1 trillion. Due to the nascent (early stage of development) quality of the technologies being investigated, it is difficult to extract accurate cost estimates at this point.

In any event, the "Star Wars" program may be the prime source of funding driving the military-industrial-university complex for the next several years. The SDI has attracted numerous defense contractors, academic labs and high tech firms wanting a piece of the R&D action. The chart presented in Figure 11.7 identifies major recipients of SDI contracts that are based in the San Francisco Bay area. After only three years into the SDI project, the state of California had garnered 47 percent of the SDI contracts awarded by the Pentagon. Interestingly enough, the same companies already at work producing the next generation of nuclear weapons are also receiving millions of dollars to develop a way to protect us from them!

The Lawrence Livermore National Laboratory is the country's leading directed-energy weapons research facility. One of its largest SDI projects is the $1 billion-plus, ground-based free electron laser. Although the SDI is supposed to be a non-nuclear program, Lawrence Livermore is also actively researching nuclear driven directed-energy weapons.

Lockheed Missiles and Space Company was awarded a huge contract to develop and test the exoatmospheric re-entry vehicle interceptor subsystem

SDI CONTRACTORS: SAN FRANCISCO BAY AREA

The chart below lists major Bay Area recipients of SDI contracts, ranked by total value of the contract, and the amount of the contract obligated.

Recipient	Total Award[1]	Obligated '83-'86[1]
Lawrence Livermore National Lab	$875,433	$201,433
Lockheed Missiles & Space	571,352	174,086
Westinghouse, Marine Division	33,055	7,574
Stanford University	22,302	9,878
SRI International	17,052	12,044
Acurex Corp.	10,728	6,685
United Technologies, Chem. Div.	7,152	1,939
Graphic Scanning/Time & Space	5,088	5,088
Olin Corp./Physics International	4,900	4,875
Army Letterman Institute	2,500	1,000
Adv. Research & Applications	1,894	1,894
Physical Dynamics	1,496	1,496
Varian Associates	1,295	1,295
Acel Inc.	1,244	680
UC-Berkeley	1,240	411
NASA Ames	1,236	1,236
Advanced Info. & Decision	1,206	900
GTE Corp.	1,118	901
Optical Coating Lab Inc.	941	882
Space Power Inc.	906	906
Lawrence Berkeley National Lab	800	800
BDM Intl./Maxim Technologies	670	670
Plasma Research	598	598
Integrated Systems Inc.	557	92
Pulse Sciences	397	397
DOE San Francisco Operations	350	350
TRW/ESL	260	260
CSA Engineering Inc.	187	183
Optimization Technology	170	170
Tinsley Labs	153	153
MMR Tech.	152	152
Litton, Electron Tube Division	135	90
Rasor Inc.	123	123
Schlumberger	115	100
FMC	106	106
Artec Associates	100	100
TOTAL[2]	**1,567,369**	**439,907**

[1] In thousands of dollars

[2] Total includes smaller contracts

Figure 11.7 List of SDI contractors in the San Francisco Bay area. (Federation of American Scientists & individual companies. Assembled by John Pike)

WHERE THE MONEY IS GOING

The Bay Area's biggest ''star wars'' contractors, based on total contracts from 1983 to 1987. The contracts, which are in millions of dollars, were assigned by the Strategic Defense Initiative Organization and other government agencies.

Recipient	Research area	Amount
Lockheed Missiles & Space Sunnyvale	Kinetic energy and surveillance systems	$1,024
Lawrence Livermore Labs Livermore	Free-electron lasers, nuclear X-rays, system and control concepts	$451.9
General Electric San Jose	Space nuclear reactors	$179.5
Westinghouse Marine Division Sunnyvale	Electromagnetic rail gun, launcher facilities and experiments	$35.8
Stanford University Palo Alto	Free electron laser, optical computing	$24.9
Acurex Mountain View	Laser resistant materials	$20.6
SRI International Menlo Park	Computing, battle management concepts	$19.2
ESL Sunnyvale	Classified, and high-speed computer networks	$16.0
United Technologies San Jose	Kinetic energy weapon demonstration	$7.2
Advanced Decision Systems Mountain View	Computer modeling	$3.4
Varian Associates Palo Alto	Power amplifiers	$3.2
Advanced Research & Applications Sunnyvale	Gallium arsenide semiconductors, flaw detection, X-ray source enhancement	$2.5
NASA Ames Mountain View	Data collection, plume attenuation	$1.7
GTE Mountain View	Intelligence and warning system, software modeling	$.96

Figure 11.7 continued.

(ERIS). ERIS will be a ground-based, very high speed, long-range weapon to intercept incoming warheads above the atmosphere. Lockheed has recently worked on a variety of directed-energy concepts. Its goals include tracking targets, directing weapons at them, distinguishing real targets from decoys, and studying how vulnerable the missiles are to energy beams.

Maxwell Laboratories, under contract to the Defense Nuclear Agency, has developed a prototype kinetic-energy weapon known as the electromagnetic railgun. TRW has received large awards for work on lasers that can be deployed in space or on the ground. Other major recipients include Rockwell, Westinghouse, Hughes Aircraft, LTV Aerospace, McDonnell Douglas, and Teledyne Brown. At the same time, academic institutions have shown a remarkable measure of hospitality for military research in recent years. Some colleges of engineering believe SDI will be the primary source of new money for basic research in the physical sciences for the next decade.

It may be true SDI will spur scientific discoveries having industrial, employment, and commercial payoffs. In the state of California alone, more than 300,000 manufacturing workers depend on weapons projects for their salaries. Despite the allure of SDI as a revolution in high technology research projects, the benefits to society may not outweigh the costs on several levels.

Specifically, SDI is predominantly a program in applied research. It is much different than the post-World War II basic research that showered us with commercial airliners and computers. A huge portion of its budget is earmarked for experiments in prototype weapons testing. Most of the laser-related hardware being designed is too large and far too powerful to be used commercially. Those innovations which might prove to have commercial potential are generally shrouded in secrecy. For instance, developments in fiber optics, new computer languages, fifth-generation computers, artificial intelligence and gallium arsenide chips may not be promptly transferred to the civilian population due to their highly classified status. It may be uncomfortable to realize that billions of dollars are being spent to develop an array of sophisticated technologies most of us hope and pray will never be summoned for use.

MILITARY TECHNOLOGY: VARIATIONS AND BLEAK SCENARIOS

THE NUCLEAR WINTER THEORY

Several years ago, a distinguished group of scientists collaborated to publish a study entitled "Nuclear Winter: Global Consequences of Nuclear Explosions."[1] The results of this research endeavor have also become known as the TTAPS study to denote the initials of its multiple authors. Dr. Carl Sagan, who acted as the chief spokesman for the team, coined the label "nuclear winter" to describe a post-thermonuclear war world that is frozen and barren of life. The term has since become a generic rubric (heading or title) for the various environmental consequences of nuclear war. The TTAPS findings and assertions have created a great deal of interest in the scientific community. The project has further stimulated the United States defense establishment to expend a concerted amount of effort to validate and refine its dismal conclusions.

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[1] R.P. Turco, O.B. Toon, T.P. Ackerman, J.B. Pollack and Carl Sagan (TTAPS). Nuclear winter: Global consequences of nuclear explosions. *Science,* December 1983, *222*(12), 1283-92.

In its simplest terms, the theory of nuclear winter is portrayed by the slight chill you experience when a cloud passes in front of the sun. It is quite a bit more complicated from the standpoint of the ever-changing patterns of wind and weather systems that swirl across the surface of the globe on a daily basis. It is based on the phenomenon as microscopic as the behavior of the individual particles within a cloud of smoke. It is predicated on events as formidable as the detonation of a thermonuclear warhead with the force of 2 billion pounds of TNT.

Generally speaking, in the event of a nuclear war, the TTAPS authors concluded that the fireballs of thousands of exploding warheads would set forests, fields, and entire cities ablaze. Plumes of dark smoke would be lofted up to the boundary between the troposphere – the lowest region of the atmosphere where weather occurs – and the stratosphere – the static weatherless region that begins 6 to 8 miles up at the edge of space. The debris injected into the upper atmosphere would absorb and scatter critical amounts of sunlight that would eventually lead to a world wide nuclear winter phenomenon.

Causes

In theory, which is further supported by three-dimensional supercomputer modeling efforts, nuclear winter is caused by the amount of smoke, dust, soot, and other particulates nuclear blasts generate. The amount of these materials present in the atmosphere at any one time is also a factor. Debris of this sort is created in two ways: burning and ground bursting. It is likely the burning urban industrial areas will create the greatest amount of intense smoke and soot. Cities are noteworthy because they are loaded with fuel in the form of plastics, petroleum, wood, and paper. Reservoirs of oil and gasoline, dense downtown high-rise buildings, and sprawling residential neighborhoods account for a high fuel density. The smoke produced by torching a city is heavier, darker, and of a greater quantity than that produced by a forest fire. The TTAPS study postulates if just 100 cities are burned, the atmosphere will literally be turned upside down creating a condition known as an "antigreenhouse effect."

The destruction of hardened military targets (missile silos) by means of ground bursting will also contribute to nuclear winter by mechanically catapulting dust and debris into the stratosphere. From a strategic military perspective, this effect is proportional to the amount of megatonnage being dedicated to counter-force targeting. This is a direct function of weapon accuracy, target hardness, number of targets, and number of weapons expended per target. Ostensibly, the greater the amount of ground bursting that takes place, the more debris will be spewed into the atmosphere.

Another causal factor to be calculated into the nuclear winter scenario has to do with the pace of destruction effected by burning and ground bursting. For instance, if a moderate number of cities (let's say 100) were set ablaze simultaneously by fire storms, nuclear winter would result. However, every city in the world could be burned without causing nuclear winter if the destruction transpired over an extended period of time. Slowing the pace of destruction might increase the possibilities of terminating the war itself before nuclear winter occurs. In short, any type of nuclear exchange which injects significant quantities of smoke, dust, soot and other debris into the upper atmosphere in a short period must be avoided.

Consequences

The TTAPS scientists conclude that, after a "baseline" nuclear war in which warheads with a total yield of 5000 megatons had been exploded over a variety of targets, a massive temperature inversion will result. The globe-girdling cloud of debris will prevent the sun's energy from reaching the earth while the heat of the earth continues to radiate outward. Darkness will cover the earth causing average surface temperatures to drop 60 degrees Fahrenheit to below freezing even in the summer months. Agriculture will be destroyed and ecosystems will be disrupted threatening the existence of life forms everywhere.

For those humans who are "lucky" enough to survive the horror and devastation of a nuclear conflict, the postwar world will be a nightmarish environment of cold, dark, and starvation. The TTAPS study also projects the possibility the high-altitude smoke cloud might spread across the equator, dismissing sensitive tropical ecosystems and the inhabitants of the Southern Hemisphere into a chilly twilight.

In the event the nuclear winter phenomenon did not result in its ultimate form, the climatological effects of debris injection are cumulative. A lower level of nuclear disruption could result in what is called a "nuclear autumn" where the average temperatures across the planet decrease by several degrees. Although there might be less dark and freezing in this scenario, the potential destruction of a single crop-growing season would be catastrophic for the human race.

The formulas, algorithms, and computer models presently being used to establish the theory of nuclear winter are filled with variables and uncertainties. What type of nuclear war might be fought? How many megatons of warheads would be exploded? (Note: One megaton is the explosive power of one million tons of TNT.) Does the war last a month, a week, or a day? Does it take place in the summer or during the dead of winter? Regardless of the answers construed for these inquiries, the stakes are quite high. If the probable outcome of a nuclear war is a widespread nuclear winter, non-combatant nations can no longer consider themselves existing safely outside the perimeter. It is evident members of the world's nuclear arms fraternity must recognize the clear and highly conceivable nuclear winter phenomenon as they continue to develop their military strategies.

BIOLOGICAL WARFARE

In becoming parties to the Geneva Protocol of 1925, more than 100 nations agreed not to wage biological warfare. This document is an arms control treaty which outlaws the use of biological weapons in war. More recently, almost the same number of countries became parties to the Bacteriological and Toxin Weapon Convention of 1972. This landmark disarmament treaty forbids the very possession of biological weapons and their associated hardware. Both agreements manage compliance and adherence via shared attitudes, mutual self-interest, and military dis-utility (belief that the harmful nature of these weapons outweighs their military usefulness). Neither one contains adequate provisions for verification, regulatory sanction, or other forms of punishment. In other words, the extent to which all nations adhere fully to these agreements is unknown.

Biological warfare has long been detested. Biological weapons are seldom used. Even still, the specter of biological warfare is difficult to ignore in light of emerging laboratory techniques that permit the development of biological weapons which may prove useful to the military. During the past decade, biotechnologists have made remarkable advances in genetic engineering. The ability to more easily manipulate the genetic codes of microorganisms might actually improve the usefulness of the potential biological weapons which already exist or the capacity to create brand new ones. A number of informed individuals have suggested the 1972 Bacteriological and Toxin Weapon Convention is not comprehensive enough to proscribe the expected fruits of genetic engineering. It may be an appropriate time to amend this treaty to correct this immediate shortcoming.

By definition, biological warfare is the use of a living organism, usually a pathogenic microorganism, for hostile purposes. Biological agents can be: bacterial, fungal, viral, rickettsial, or protozoan. Toxins are not biological weapons and they are discussed in the proceeding section on chemical agents. An exhaustive digest of likely biological agents is next to impossible to assemble for several reasons. First, the shear number of potentially harmful organisms is huge. The potential targets, including many animals and plants in addition to human beings, span a wide spectrum. The effects of the agent will range from lethal through debilitating to irritating depending on the immune system of the victim. Further, the scope of potential delivery methods is complex ranging between overt (open) and covert (hidden) techniques, as well as direct and indirect inflictions (e.g., an aerosol spray vs. the use of an infected vector [in pathology, a vector is an organism that carries infectious pathogens from one host to another]).

Regardless, biological agents share several distinct characteristics. First of all, they are all living pathogens used to produce a disease, typically lethal, in their target host. Second, they have the capability to spread beyond their initial site and precise moment of attack by multiplying and infecting other vulnerable hosts. Finally, since they are groups of living organisms, they will act on groups of other living organisms. Depending on extant (current or existing) field conditions, their initial effectiveness and subsequent spread will vary a great deal. This makes their behavior all that much more difficult to predict.

Operationally, biological agents are not precision-targetable weapons. Since they are indiscriminate, they are not generally considered useful as tactical weapons on the battlefield. Their widespread impact, however, signals their use as a weapon of mass destruction. Some anti-personnel agents might also damage livestock and other animals. Conversely, anti-animal agents might harm human beings. An onslaught with anti-plant agents could lead to rampant civilian food shortages and starvation. They might also create severe ecological disruption, soil erosion, and other site debilitation. The following list identifies several known agents which clearly have serious and far-reaching effects on all organic life forms.

1. **Yersinia pestis** = a bacteria which causes plague or black death.
2. **Francisella tularensis** = a bacteria which causes tularemia, or rabbit fever, characterized by swelling lymph nodes.
3. **Brucella abortus** = a bacteria that causes brucellosis, an undulent fever marked by weakness and painful joints.
4. **Salmonella typhi** = a bacteria that causes typhoid fever, a deadly disease characterized by red rashes, high fever, bronchitis and intestinal hemorrhaging.
5. **Bacillus anthracis** = a bacteria that causes anthrax, or Siberian ulcer, a usually fatal disease.
6. **Coccidioides immitis** = a fungus which causes desert fever, rarely a disease of humans, but results from a digestive tract infection.
7. **Toxoplasma gondii** = a protozoan which causes toxoplasmosis, characterized by lesions in the brain and eye, especially among infants.
8. **Rickettsia prowazekii** = a rickettsia carried by fleas, ticks, and lice, when transmitted to man, causes typhus and Rocky Mountain spotted fever.

Several of the known viruses that remain high on the list of potential biological agents include: Rift valley fever, eastern equine encephalitis, smallpox, and yellow fever.

If reading through this list has made you somewhat uneasy, you are certainly not alone. The persistent and common horror aroused by the technology of biological warfare may stem from our acquaintance with disease and sickness. Both are normally associated with long-term pain, suffering, and tragic death. The armed forces of the world have rarely used biological weapons. Using disease as a weapon invokes disgust and these organisms are not very useful from a military perspective. Officers widely consider the use of biological weapons to be dishonorable, unethical, and treacherous.

Nations do not readily admit to having biological weapons in their arsenal. At least three nations have possessed biological weapons in the past: Japan during the 1930s and 1940s; the United Kingdom during the 1940s; and the United States from the 1940s through at least the 1960s. Possession of such weapons by the Soviet Union has been alleged. The United States claims an outbreak of anthrax in Sverdlovsk in the late 1970s resulted from an accidental release of *Bacillus anthrasis* from a nearby Soviet biological warfare research center. Soviet officials vigorously deny the allegation and attribute the outbreak to the illegal sale of contaminated meat. The issue remains unresolved due to an insufficient amount of reliable information.

Biological agents are relatively easy and inexpensive to produce for any nation with a modestly sophisticated pharmaceutical industry. Research, development, production, and even dissemination of biological weapons could be disguised as civilian activities or easily kept secret. The world leaders cannot afford to wage an adverse biological arms race. It is essential all industrialized as well as developing nations reaffirm the treaties signed earlier and amend them as necessary to abate the potential for disaster as soon as possible.

CHEMICAL WEAPONS

Approximately one million persons were killed by chemical weapons during World War I. The Geneva Protocol of 1925 subsequently banned the use of poisonous, asphyxiating or other gases. However, it did not ban their development, production, stockpiling, or deployment. The United States and other nations therefore continued to produce chemical weapons. Nazi Germany developed a nerve gas much more lethal than those used in the first World War. Luckily, chemical weapons were not used during World War II. During the Nixon administration, the United States reaffirmed its renunciation of the first use of lethal chemical weapons (but excluded tear gas and herbicides) and pledged that it would never engage in germ warfare.

Shortly thereafter, the United States and the Soviet Union reached an accord on biological weapons. This was most likely because their unpredictable nature made both sides hesitant to use them. However, they were unable to come to terms on a ban of the production and stockpiling of chemical weapons since they could not agree on a method of verification. The United States production of chemical weapons fell considerably during the late 1960s all the way through the 1970s. The Reagan administration resurrected the idea of chemical weapons production in the early 1980s. The desire to produce a new generation of chemical devices known as "binary" weapons stirred a lot of controversy. Several NATO members declared they will not allow shipments of chemical weapons to U.S. forces based on their territory. International negotiations for a global ban on chemical weapons have been conducted by the 40-nation Conference on Disarmament in Geneva since the late 1960s.

Chemical weapons including mustard gas, chlorine and phosgene were used during World War I, first by the Germans, and later by the Allies. Nerve gases invented in the 1940s, including tabun, sarin and, soman, are highly volatile vapors that disperse very quickly. Following the second World War, United States and British scientists developed vx, which is a more toxic, persistent, and quite deadly nerve agent.

Each of these poisonous gases affect humans when it is either inhaled or absorbed through the skin. They work by inhibiting the action of a key enzyme in the body. By name, acetylcholine esterase is critical to the transmission of chemical messages from nerve cells to virtually all muscles in the body. Muscle paralysis ensues, causing death by asphyxiation. In non-lethal doses, these chemical agents cause partial paralysis, dizziness, vomiting, and diarrhea.

Chemical weapons and nuclear weapons are similar from the standpoint that their use directly affects civilian populations. Chemical weapons cause death among unsuspecting civilians who have no protective equipment. Nerve gases are so dangerous that any leak, spill, or accidental release can devastate life downwind. The uncontrolled spread of nerve agents by wind beyond a specific military target area could be a particularly serious problem when forces are fighting on their own home territory.

Amidst the controversy over chemical disarmament, Congress appropriated over $150 million to begin replacing the Defense Department's current stockpile of obsolete chemical weapons with binary weapons. The unitary munitions presently contained in the stockpile are between 15 and 40 years old. These weapons contain a chemical agent which is already toxic. In contrast, binary weapons are supposedly safer to store and handle. These contain two inert chemical substances which become lethal only when mixed together upon firing. See Figure 11.8. Production of these replacement weapons will inevitably commence in the near future.

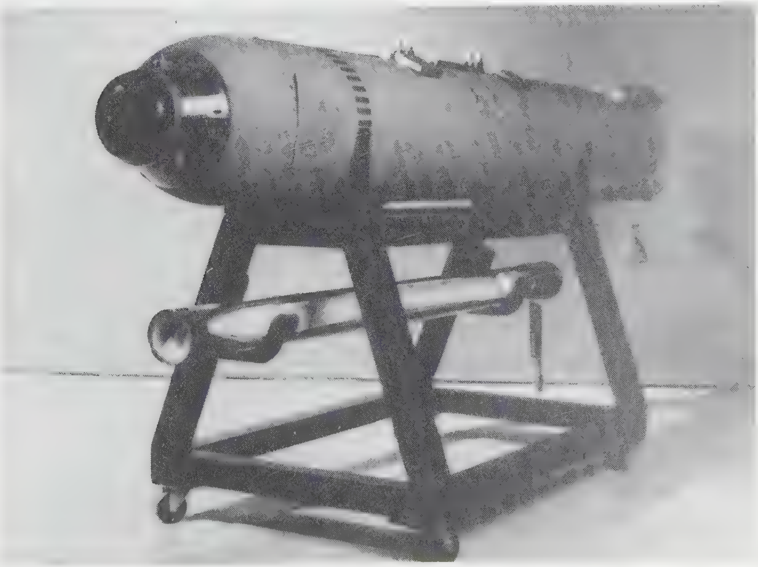

Figure 11.8 The BIG EYE bomb, an aircraft-delivered binary chemical bomb. This is the first weapon to generate a persistent nerve agent from two non-toxic chemicals. The non-toxic agents are shipped and stored separately, eliminating the possibility of toxic agent formation prior to a mission requirement. The BIG EYE is a joint USN-USAF development program and will be compatible with most USN and USAF tactical aircraft. (Department of Defense)

At the heart of the decision to recommend further research and development in this strategic field of defense science lies the concept of chemical deterrence. Possession of chemical weapons will evidently provide the United States with a strong and effective deterrent to their use around the world. Chemical weapons are more accessible to terrorists and Third World nations than are nuclear weapons. The ensuing threat of a chemical attack against United States troops is not limited to a Soviet attack in NATO Europe. It appears to be a world wide peril. Binary munitions are safer and easier to transport. They should provide the United States with the flexibility necessary to deter the threat of chemical warfare in any location. On a different tack, the full-scale production of a new generation of chemical arms will probably undermine the opportunity for chemical disarmament in the foreseeable future. It may also jeopardize the United States' diplomatic relations with other NATO countries.

THE FUTURE??

"Black budget" is the Pentagon's own term for projects hidden from public view by classifying their titles, costs or objectives. Black projects are concealed in numerous ways. In many cases, their costs are simply deleted from the unclassified budget. Some are tagged with innocuous code names like "Elegant Lady" or "Elusive Dancer." Estimates report nearly one-fifth of all Pentagon spending for weapons development and production is hidden in black budgets for research and eventual procurement.

Some future-focused defense scientists envision an alarming defense strategy where the United States is able to fight and win a six-month nuclear conflict—World War III—and remain strong enough to strike again in something called World War IV. Long after most of us have perished and the White House has been reduced to rubble, their strategy calls for computers to run a war no human mind could, or would even want to, control. The key to this strategy, of course, is to build an amazing computerized network to command and control the nation's nuclear forces. This visionary network has lovingly been dubbed "C^3I" (pronounced see-cubed-eye) which is short for Command, Control, Communications, and Intelligence.

A major component of the nuclear C^3I system is a multibillion dollar satellite system known as Milstar being funded by the Pentagon's black budget. The Milstar system of satellites will orbit 70,000 miles above the earth in order to receive and relay commands to launch nuclear weapons. The Milstar satellite network would reportedly connect thousands of radios and computer terminals in military headquarters, underground bunkers, missile silos, submarines, tractor trailers, and airborne command ports. Essentially, it would represent the global switchboard to receive and relay launch orders for nuclear weapons. Two other C^3I systems are reportedly enshrouded in the black budget. The first are satellite sensors designed to guide nuclear missiles in flight, track their progress and report back on the damage they inflict on the enemy. The second consists of tractor trailers hauling nuclear command posts, dodging Soviet attacks on open stretches of the nation's interstate highway system. The C^3I

projects found in the unclassified Pentagon budget are related to computerized efforts to orchestrate a complex network of nuclear weapons over a global battlefield.

Meanwhile, the Pentagon's Defense Advanced Research Projects Agency (DARPA) is busily working on a variety of computer-controlled robots that can gallop like horses and walk like men across a lethally radioactive battlefield. DARPA envisions a robotic soldier of the future that takes orders but does not talk back to its superiors. Who will these techno-troops take orders from? You guessed it—a supercomputer lodged in some underground military command center or afloat on board a Milstar satellite!

The new generation of C^3I satellites is another step toward the militarization of space. In some ways, it appears to be complementary to the SDI project. In others, the two programs seem to contradict each other. The C^3I network allocates the majority of the power over our nuclear forces to computers. Much of the technology remains uncertain at present, but it is probable these black budget items will continue to provide a fair number of defense scientists and military technology experts with gainful employment during the upcoming years.

SUMMARY

We find ourselves living amidst a vast array of technological conveniences in the shape of personal computers, compact disc players, wonder drugs, nutritionally enriched foodstuffs and superior optical devices. Just down the road, the same basic research that delivered several of these items is in many ways responsible for the specter of our strategic defense technologies. This chapter addressed the topic of national security as it relates to international defense strategies and policy-making.

Nuclear weapons have become the primary focus of political discussions regarding the capacity to protect one's citizens from an opponent's aggressive force. Nuclear weapons have symbolically become the icons (image or symbol) of war and peace at the same time. We are fraught with conflicting perceptions concerning policies bearing the label deterrence—nuclear deterrence, strategic deterrence, tactical deterrence, chemical deterrence and so forth. Should we continue to design, develop, and deploy more lethal weapons as time goes on? Or, should we make a decisive commitment to reduce our current stockpiles of chemical, biological and nuclear weapons?

To most officials in the United States and Soviet defense establishments, and probably to most U.S. and Soviet citizens alike, the fruits of our military technology exemplify an ultimate recourse. Weapons of the type described in this chapter really do exist—they are not figments of our imagination. Although we can not ignore their existence, most of us it seems, hope that these lethal devices will never be used. Government leaders seem to view their military arsenals as a necessary force their constituents have given them the authority and responsibility to discharge if needed. Perhaps we can hope to cut the numbers of weapons systems to a minimum and avoid future deployments which will not add to deterrence or defense. We can not hope to avoid technical change. Unfortunately, change is imminent. And, while deterrence, as an international defense policy, may not be the ethical, moral, or intellectual choice of all persons, it may be the only choice we have. If deterrence is coupled with a healthy dose of cooperative diplomacy, the world should continue to be an OK place to live.

DISCUSSION QUESTIONS

1. Explain the defense strategy labeled Mutual Assured Destruction or "MAD."
2. What is the difference between counter-force targeting and counter-value targeting? Provide examples of "hard" and "soft" targets in your response.
3. Identify and describe the phases through which a contemporary ICBM will travel after it is launched by one of the leading nuclear powers. A diagram may be of assistance.
4. Describe several reasons why it may not be possible to post chemical lasers or X-ray lasers on space-based battle stations.
5. What is meant by the theory of "nuclear winter?" How do these conditions differ from a "nuclear autumn?"
6. Prepare a brief essay which describes a plausible profile of international defense strategy during the next two decades. Give specific examples in your discussion.
7. How do you feel contemporary government leaders should go about redefining their perceptions of national security? Do you believe deterrence and diplomacy can make the world safe for future generations? Why or why not?

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Chapter 12

SOCIAL RESPONSE TO TECHNOLOGICAL CHANGE: BREAKTHROUGHS AND RISKS

DATELINE

Baltimore, Maryland

Following a meeting of the National Technological Literacy Conference, many atendees seemed convinced a large percentage of the American public is technologically illiterate. Stated differently, we seem to be graduating students who are not prepared to grasp the technical content of day-to-day issues. Some college graduates are reportedly unable to comprehend the social impact of technology issues ranging from the safety of contraceptive devices or food additives to robotics, gene splicing, nuclear accidents or the explosion of a space shuttle. Faith in technology, it seems, is not always accompanied with an equal measure of understanding.

Although it is rare to find very many people who lie awake at night wondering whether or not electricity is ''mysteriously dripping out of empty wall sockets'' (a common misconception in the early days of electrification), most people probably live with some form of high-tech anxiety. There are those ''techno-dummies'' among our lot who either believe everything the experts in the white coats tell us, or hysterically reject everything they tell us since the products and systems of technology usually go awry. Others among us may be labeled ''techno-wizards'' since they are the ones who appear to know what they are doing when they use technology. The ''techno-dummies'' rely on the ''techno-wizards'' when their telephones don't work or their computers break down. Perhaps it is this distinction that provides the basis for technological literacy in our society . . . .

INTRODUCTION

Contemporary science and technology have created the amenities (comforts) of modern civilization. In countless ways, each has increased our capacity to control environmental forces and has given us visions of an even more prosperous future. Undeniably, science and technology have also increased both our uncertainties about the future and our dependence on the numerous inventions and innovations they have produced. Stated differently, while we may have increased our ability to understand, predict, and control the natural environment around us, we may have actually lost the capacity to control the technologies we have created to help us out along the way.

Technology and its impact on society at large has been a prevalent theme in social, economic, and political thought for decades. Numerous essayists have debated about the extent to which continued technological growth will either enhance or hinder the survival of the human race. A diverse collection of writers have drawn our attention to the increasing complexity and rate of technological change in contemporary society. Almost habitually, they seem to be making projections filled with varying degrees of alarm. Their publications present the specter of an increasingly uncontrollable technology spreading like a cancer among the population. Its consequences can not always be assessed or accurately predicted. We are drawn to infer the human race is on a collision course to ruin and imminent destruction in the near future.

On one side of the debate, social scientists, policy makers, and technologists alike take the position that society should critically examine the role it wants technology to play and then take action to curtail its destructive tendencies. On the other side, similar groups of professionals assert that more scientific and technological research (knowledge and information) is all that is required to cure all of society's illnesses. In some ways, the debate seems to be perpetuating itself!

While the rhetoric continues, we are living amidst an array of technologies some persons contend are simply accidents waiting to happen. When the dark side of technology reveals itself, when disaster hurts the innocent bystanders, and when technology causes more problems than it solves, society often points the finger of blame at its creators. When "accidents" do occur, the general public shakes its head while wondering what is happening to its "technological fix." Regardless, there is little chance the industrialized nations of the world will turn their backs on the promises aligned with new technologies. We have all chosen a life-style sustained by high technology. But, that doesn't mean we are not apprehensive about it.

Just a few decades ago, we were, for the most part, blissfully unaware of the potentially harmful effects of man-made chemicals on ourselves and the environment. We were unconcerned about the finite nature of the raw materials and resources that were being depleted to fuel technological progress. These days, as our reliance on science and technology intensifies, we have begun to worry about the effects of acid rain on our lakes and forests. We worry about the future consequences of the build-up of carbon dioxide in the atmosphere.

We worry about what is happening behind the closed doors of weapons research laboratories. We are fearful chemical dump sites may be leaking into our supplies of drinking water. We also worry about which foods are safe to eat and which drugs are guaranteed to not have harmful side effects on our progeny (offspring). It seems a greater amount of information regarding all the technological conveniences we take for granted has most directly created a higher level of social anxiety.

Further, as the demand for energy to drive the massive engines of science and technology increases, so too does society's concern about the sources of future supplies and the ramifications of exploiting our current energy technologies. These anxieties range from the disposal of radioactive wastes to the political and economic consequences of our dependence on foreign oil. None of these issues comes with a "handbook," a "set of instructions," or a "glossary of terms" to chart a definitive course of action for all of humanity. Technological growth is replete (filled) with a series of uphill struggles – but then, it always has been.

The current international proliferation of technologies has led to an exponential widening of risk for all of the earth's inhabitants. The social excuse of being "an innocent bystander who is not responsible for technology" is severely outmoded. The concept of "universalism" is more evident today than ever before. This characteristic of modern technology refers to both an interdependence among nations and the diminishing number of "unaffected" cultures. Technological developments and the risks associated with them do not exist in a vacuum.

This chapter is structured to assist you in your evaluation of how technology and its associated risks affect all social groups – regardless of their level of technological development. The various sections present some of the issues pertinent to society's capacity to accept technological change and simultaneously take responsibility for its by-products. It is next to impossible to precisely distinguish a "good" technology from a "bad" one. Yet, if society expects to benefit from the fruits of its scientific and technological labor, it must retain the strength to control and direct the course of its activity. In order to keep science and technology "on track," so to speak, it is necessary to conduct routine risk-benefit analyses blended with a heavy dose of information, logic, and common sense.

1. What are the implications of the accelerating rate of scientific and technological change for society at large?
2. Are there any particularly effective strategies we can use to cope with the pitfalls associated with "social lag?"
3. Is society "at risk" by virtue of its ever-increasing dependency on the fruits of technology and science?
4. How does the concept of "technological illiteracy" fit into the threads of our contemporary social fabric?
5. Is it plausible to trust in the experts' abilities to carefully scrutinize the development of new technology in order to ascertain whether or not it

should be endorsed or abandoned?

6. Should these "technocrats" really be authorized to decide whether the inevitable risks outweigh any reasonable benefits with reference to unproven technologies?

KEY CONCEPTS

Many of the terms and phrases that are commonly used in the science, technology and society (STS) literature may already be familiar to you. A few of them are listed here and will be mentioned in this chapter. You should be able to explain what is meant by each of them when you finish your review of this material.

Social Lag
Technological Literacy
Busyness Syndrome
Organizer
Technology Trap
Information Overload
Technology Accordance
Durational Expectancy
Universalism
Response Modes
Social Techno-hypnosis
Risk-benefit Analysis

THE GENERAL NATURE OF CHANGE

The key word in the title of this chapter is "change." The next word, based on its level of importance, is "response." Before attempting to discuss response modes that social group members rely on to deal with change, it is essential to understand the meaning of this elusive construct or term. Throughout history, in the simplest terms, change has been the only constant. In essence, change is constant—it is progressive—it is universal. Change is not always as great or far reaching as we sometimes imagine it will be. And, to repeat a timeless phrase, the more things change, the more they are the same.

If these assertions are valid, why do people fear change? Why do social groups band together to fight against change? Why do some individuals feel inclined to avoid making changes at any cost? And, why do some professionals go on record saying things like: "I don't mind progress as long as I don't have to change!" The word change produces emotional reactions since it is not a neutral word. To many people, change is threatening. Without any sort of modifier, the word change promises no respect for present cultural values. Change may even disrupt the values themselves.

In some instances, the mere mention of a proposed change conjures up visions of revolution, dissatisfaction and discontent. More euphemistic (agreeable or inoffensive) words which refer to the process of change include education, training, modification, orientation, guidance, indoctrination, and therapy. We are much more amenable to a situation where others "educate" us versus one where others "change" us. We tend to feel less guilty if we view ourselves as "training" other persons rather than "changing" them. These substitute words are safer or less emotional, which is why they are more tolerable. At first glance, they carry the implicit assurance that the only changes produced will be good ones compatible with society's current value system. Unlike the assortment of synonyms presented above, the word change is crisp and directional. The word change is not lost in the translation of a phrase or couched in preconceived expectations. Take a moment to reflect on *your* personal ability to confront changes head-on and deal with them as they surface in your daily living arrangement. Within a very short period of time, it should become obvious to you there are two basic forms of change: *theirs* and *ours!* This might provide a basis for the fact that society's feelings about change are often contradictory. On one hand we welcome change, and on the other hand we fight against it. We acknowledge *our* individual rights to stimulate change but oppose *their* right to make changes occur. See Figure 12.1.

Social groups display an uncanny ability to cope with adversities. However, they have a great deal of difficulty coping with uncertainties. The uncertain element of change is frightening and often threatening. Uncertainty suggests change that is beyond *our* control. This implies a union between *uncertainty* and *them*.

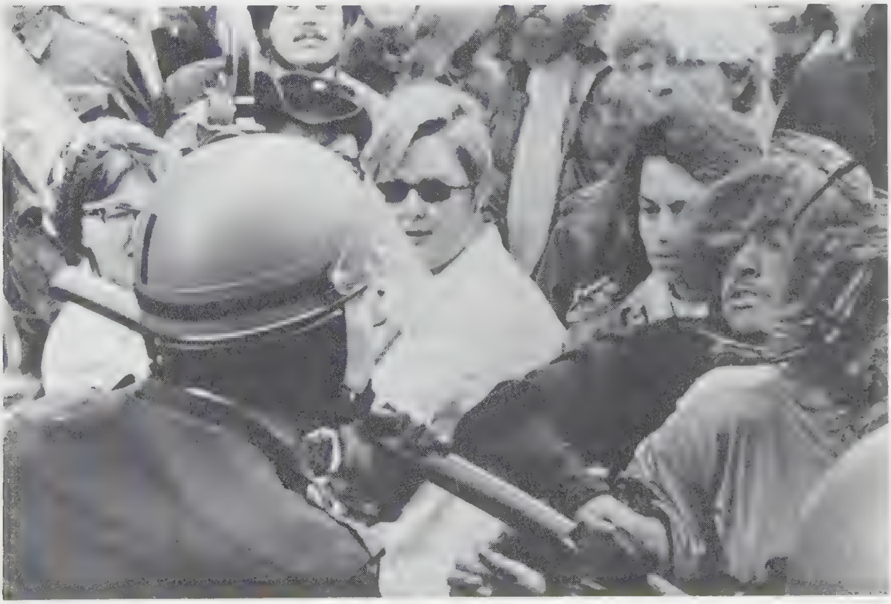

Figure 12.1 Numerous peace demonstrations were organized during the late 1960s and early 1970s. These activities often revealed that personal beliefs are not always sanctioned by the legal sector of society. The original caption for this photo taken in 1970 read: "Protestors were herded by police up California Street in San Francisco into the main line of march. An estimated 5,000 persons gathered in front of the Fairmont Hotel to protest the visit of South Vietnam's Vice President, Nguyen Cao Ky. Small outbursts of violence occurred when police attempted to clear various adjacent areas."
(Spartan Daily Newspaper, San Jose State University)

One tenet of social behavior states: If you want persons to be supportive of a change, make them believe they had a part in bringing it about. Consider the production manager who makes the decision to move the hourly employees' break period from 10:00 a.m. to 10:45 a.m. Rather than adamantly posting this announcement on the bulletin board next Monday morning, this person would be wise to involve all those affected by the change in the decision-making process. The main objective should be to convince the employees that: (1) the change will be beneficial for them; (2) their input is valuable; and (3) they possess a measure of control with regard to their working environment.

Although it is not always possible to be in total command of changes that affect our lives, it is possible to assume a profile of "readiness." Readiness to make changes implies a willingness to take charge of any number of unanticipated situations – it does not imply "whimpy" behavior. We really do have the capacity to make *their* changes *our* own if we keep abreast of developments taking shape each day. The real challenge in the modern world is not so much related to a willingness to accept change per se, but to the speed with which we are willing to do so.

PACE OF CHANGE

If you have ever had the occasion to "eavesdrop" on a lively discussion where the participants were reminiscing about the "good old days," the chances are at least one of the members says something about the pace of change. When persons reflect on the past, they have a unique tendency to perceive the events from a nostalgic or sentimental perspective. They remember people seemed to be less harried and technical changes appeared to occur at a much slower rate. It is typical to view the changes that took place in science and technology a few decades ago as evolutionary and to describe the ones happening right now as revolutionary.

We, as a society, are bombarded with marketing phrases like "new and improved," "now, with even more power," and "hurry, offer ends Friday" on a daily basis. We have become accustomed to this hectic pace of change, but not everyone is able to tolerate it. Technology in all disciplines is changing so quickly individuals often believe if they understand certain information today, it must be obsolete. Further, consider this idea: More technological innovations have transpired *since* you were born than the number introduced *before* you were born! In other words, technological advancement has accelerated to a point such that a span of less than three decades can easily contain more developmental breakthroughs than a span of several hundred centuries.

Some futurists tell us the breakneck speed at which science and technology changes will occur within the next couple decades will make today's stride seem like a snail chasing a turtle. In the 1970s, Alvin Toffler's critically acclaimed *Future Shock* cautioned us about the physiological and psychological maladies (disorders) persons experience when they are forced to deal with too much change too quickly. He introduced us to new phrases like information overload, durational expectancy, and throw-away society. Each of these concepts is directly related to society's acceptance of change and its capacity to assimilate change very quickly.

On a personal level, INFORMATION OVERLOAD refers to an individual's inability to think clearly due to an excessive amount of cognitive stimulation. Overloading the human nervous system with too many bits of information (stimuli) at one time causes a breakdown in performance and logic. When this type of system demise is examined on a social level, data seem to imply that society does not respond well to what might be described as an information explosion. Once again, the element of "speed" surfaces through the choice of the word "explosion" to describe a social condition. As change continues to accelerate in society, it forces a parallel acceleration within each of us. Each time new information reaches us, we are pressured to revise and update our master image file—older, more comforting images are continuously replaced with newer, less familiar items.

Some of our capacity to tolerate the pace of change in our daily lives has its roots in the earlier childhood years. From the moment of birth, mankind's perception of time is closely aligned with his internal circadian (biological cycles recurring in 24-hour intervals) rhythms. The manners in which he responds to time, however, are culturally conditioned. One of the first things a child learns about time involves an understanding of how long things last. This knowledge eventually leads to the formulation of a vast array of what Toffler labels DURATIONAL EXPECTANCIES. Young children are quick to learn that "in a few minutes" means something more immediate than "the day after tomorrow." Parents can explain the concept of "tomorrow" by making reference to the activity of going to bed at night and waking up again the next morning—that is tomorrow. For very young children, the concept of "yesterday" refers to every day they have been alive.

As adults, virtually all of our activities are based upon certain assumptions or expectations about durations. We expect a visit to the dentist to last longer than a trip to the post office but shorter than an excursion to the theatre. We make assumptions about the relationships we have with certain individuals—indeed, we believe that some interpersonal agreements (marriage) are supposed to last a lifetime. Durational expectancies will differ from one culture to another, but they tend to be deeply ingrained into the pace of life. When the pace of change is altered, these durational expectancies are shaken up. The resultant social response to either an accelerated or even a decelerated rate of change will range some place between immediate adaptability to an acute withdrawal from reality.

Those persons who adapt quickly to changes in their lives have most probably internalized the principle of acceleration. An individual who anticipates certain situations will endure for shorter and shorter periods as time passes is less likely to be caught off guard than someone whose durational expectancies are intractable (not easily altered or manipulated). The pace of technological change in today's world is such that many of us wonder if the word "permanence" should even be included in the dictionary.

Human beings have apparently begun to resign themselves to the notion that their relationships with certain items are increasingly ephemeral (short-lived). The fleeting nature of the vast number of technological convenience products in the home is further testimony we have become a throw-away society, Figure 12.2. Some parents are actually quite reluctant to allow their children to view Saturday morning television programs for fear that they will discover that their "newest" wonder toy has been supplanted by an "even more challenging" electronic play thing. Household consumers invest in new appliances which do everything short of eating their food only to be informed in the following week's news magazine the particular model they purchased is already obsolete. Other technology skeptics sit back and wait for the "newer" model believing it will ultimately cost less and perform more tricks. In the interim, these hesitant consumers observe the conveniences they are missing with envy. Neither of these emotions seems very pleasant.

Figure 12.2 A stroll down the "Paper Products" aisle of your local supermarket or drug store provides numerous examples of disposable items taken for granted and purchased as a matter of course in our society. These items provide a measure of convenience but also reinforce the short-lived nature of many products in our homes. (Michael Dafferner)

Regardless of your ability to deal with an accelerated rate of information overload in a world where obsolete technologies prevail, you can not deny the fact that the relentless pace of change gets trying at times. Most of us experience the need for a rest periodically, but seem to rejuvenate ourselves quickly in order to jump back into the fast lane. While many social observers spend their time discussing the ailments associated with erratic change, a considerable segment of modern civilization seems to thrive on it. Increased conveniences afforded by scientific and technical advancements have seemingly produced a culture of quickness.

INSTANT GRATIFICATION AND THE BUSYNESS SYNDROME

Do you remember the timeless cliche that says "good things come to those who wait?" How do you think the busy corporate executive on the fast track to success would respond to that suggestion these days? Contemporary American society is caught up in the need to be busy all the time and has no time to wait for anything. In response to the spirit of constant movement, science and technology continually provide numerous artifacts designed to meet our desire to have something called "It All." Having "It All" generally includes an onward and upwardly mobile career, a warm and fulfilling family life, a lean and mean body, and influential status in one's local community. To be well off on all fronts, one must be outwardly busy at all times. Our fast-paced society is ill-bent on instant gratification and is terrified of having nothing to do. What a paradox!

The modern technological household in the United States is a resplendent island of convenience. A quick stroll through the high-tech kitchen will reveal digitized dish washing machines and microwave ovens that talk to you while they humiliate last Sunday's frozen fried chicken in less than seven point six minutes. You might even spot a personal computer perched on top of the butcher block that will plan meals, provide nutritional information, and guide the user through the necessary calculations to scale down a recipe that serves 12 in order to prepare dinner for 2!! See Figure 12.3.

If you stop to glance into the "broom closet," you might spy a power driven vacuum cleaner and an iron that shuts itself off automatically. The modern bathroom is devoted to satisfying a number of contemporary hedonisms (pleasures). For instance, the bathtub is complete with sixteen jacuzzi jets, the mirror is framed with three different types of lighting, there is a water resistant radio mounted in the shower for listening to the news rather than reading the newspaper, a microprocessor controls the scale to announce the owner's weight in a digitally synthesized voice, and a classic English heating unit warms up the residents' towels while they sleep. The "medicine cabinet" is full of remedies for one ailment or another and each of them promises "fast" relief. Who would purchase an aspirin-like product that insists it will "slowly remove those aches and pains from your tired body?" Are you kidding? This is the era of instant gratification!

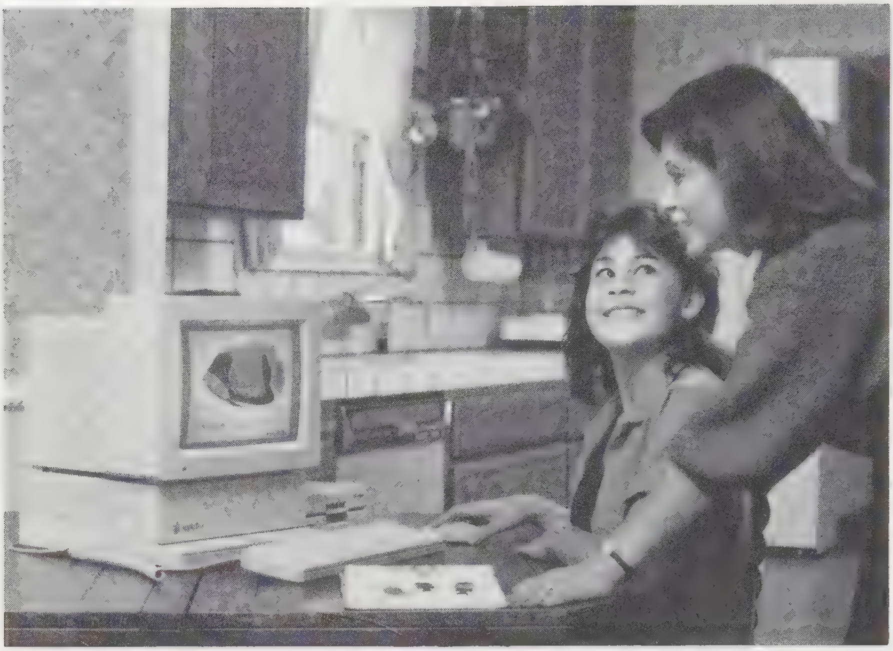

Figure 12.3 While the mother and daughter shown in this photograph may not actually be planning the family dinner for that evening, the use of a personal computer in the kitchen is noteworthy. The Apple personal computer is intended for people who have both educational and home-based productivity applications. The compatability of the Apple with the thousands of software packages available makes it well-suited for homes with school-age children. (Apple Computer, Inc.)

Another island of technological wizardry is encased in what is fondly referred to as the home entertainment center, Figure 12.4. It makes one stare in awe as the compact disc player, videocassette recorder, and the remote controlled dual screen television ensemble reside in harmony along the entire wall of a normal size room. When the stereo system is turned on, it resembles the control panel of the space shuttle—it assures its listeners, through the magic of blue LED bar graphs, green horizontal zaps of light and constantly quivering needles, that 20 year old Beatles albums sound exactly as they should. The high-tech entertainment center certainly entertains its owners. It enables the viewer to watch two programs at once, record a third one, and preview the highlights of a live football game in a small insert found at the lower corner of both screens! That certainly sounds a lot like information overload, but it also provides a great deal of instant gratification.

In a slightly different vein, Americans may still value such business ethics as courtesy, reliability, and economy. But what really impresses them is speed. We demonstrate this through our affinity for such things as one-hour photo developing services, instant replays, memory-redial telephones, and posh suntanning parlors. After all, tanning the old fashioned way takes up too much

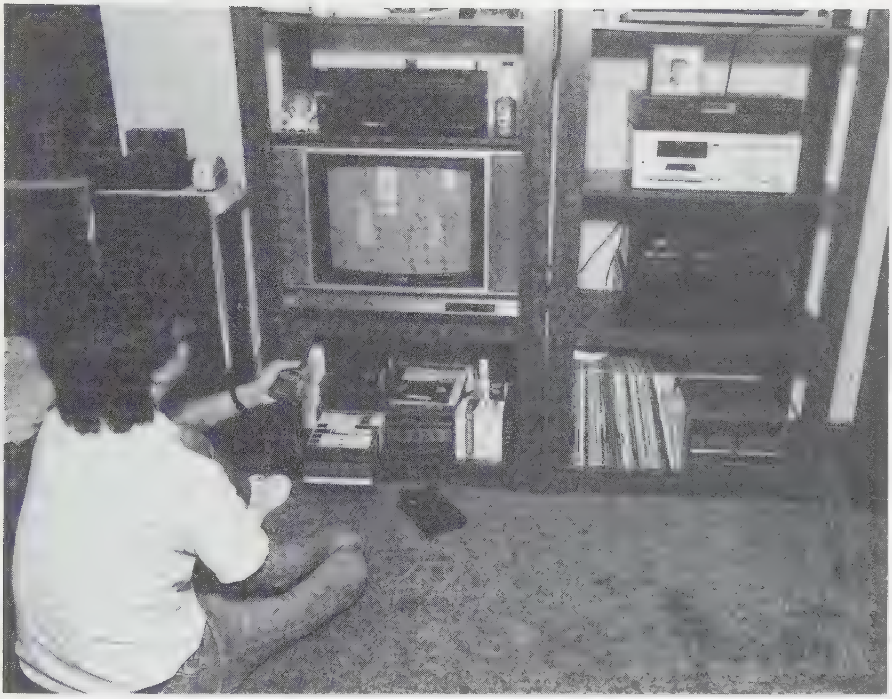

Figure 12.4 Individual reliving some happy memories as he reviews a videotape of his own wedding ceremony. This is a recent addition to the list of services offered by today's wedding photographers. Notice the use of the remote control device to ''Zip'' through the less exciting parts! The VCR is surrounded by other electronic components comprising a well-appointed home entertainment center. (Michael Dafferner)

time! Americans value speed and a number of United States corporate empires were built for all these people who like to be in a hurry (McDonald's, Federal Express, Domino's Pizza, and Polaroid). Advertisements for one convenience store criticize full-service grocery stores where customers are required to wait on long lines to purchase a quart of milk. Their mid-1980s jingle promised to "keep you revving at 7-Eleven!" And here again, the need for constant movement is exemplified.

Astute business planners recognize Americans often refuse to wait in line. Rental-car firms still experience their share of bottlenecks, but they have tried, with much publicity over the past few years, to whisk customers into their awaiting vehicles. Airline companies have started to sell tickets through vending devices called Flying Machines which dispense boarding passes in less than sixty seconds. Most major banks provide automatic-teller machines for their extremely busy depositors. Across the nation, supermarkets have made an attempt to improve their slowpoke performance by reserving one, two, and sometimes three lanes for express check-out service.

On the other hand, refusing to wait may mean missing out on an event or losing the opportunity to purchase a motor vehicle at a reduced price. Although most of us hate to wait for anything, the classic military refrain, "hurry up and wait," has become a fact of modern life. We wait in traffic, we wait for buses and trains to arrive, and we wait to be seated in crowded restaurants. We efficiently line up to buy tickets for trains which leave late and for movies that never start on time. Waiting is an unpleasant exercise—and it seems to be on the rise in our society.

As a greater and greater portion of our technology-dependent population commits itself to the doctrine of the busy class, the lines are getting longer. Waiting is a power game—persons who hold high-status positions generally don't wait as long as those who are part of the general working class. Similarly, busyness is akin to status in our country—persons who always have full calendars are usually the same ones who hold more status in the corporate business world. This is an excellent example of the contradictory nature of the current social buzzwords: instancy and busyness. Where one goal is attained, the other is curtailed.

The theory of the busy class is based on the notion that keeping a calendar filled proves you are in demand. Interestingly, calendars and schedules have their roots in religion. They were popularized in the sixth century by the Benedictine monks who believed it was a sin to waste God's time. It is ironic to note the conspicuous "organizer" in today's business world has actually taken on a whole new aura of reverence.

Figure 12.5 presents an advertisement for one company's daily organizer. These products are commonly described as a portable set of calendars with an address/telephone book and other peripherals such as sections to record auto mileage expenses and a small tablet of graph paper to satisfy that sudden urge to draw up plans for a new backyard deck. Daily organizers range in price from a modest $15 to well over $100. They often contain three different types of calendars: daily planner pages to list hour-by-hour obligations up until 6:00 p.m.; the basic year-at-a-glance format; and the 6-year planner for the time conscious professional. Anyone who requires three calendars for only one life must indeed be very busy. The diligence with which its owner fills it out, keeps it up-to-date, and retrieves it from a briefcase for consultation almost resembles a religious ritual. Perhaps the organizer is really designed to serve as a stabilizing anchor in a fast-paced, constantly changing society.

Another ingredient of the busyness syndrome is found in the burgeoning technology of the communications industry. We now have electronic accouterment (trappings or options) such as call forwarding, call holding, memory dialing and speaker phones. These features allow people to operate like CEOs in the comfort and privacy of their own home offices. Household consumers can put plumbers and gardeners on hold while checking their references with the Better Business Bureau on another line. In order to be in constant communication with important contacts while also in transit, a large number of busy persons have installed telephones in their automobiles.

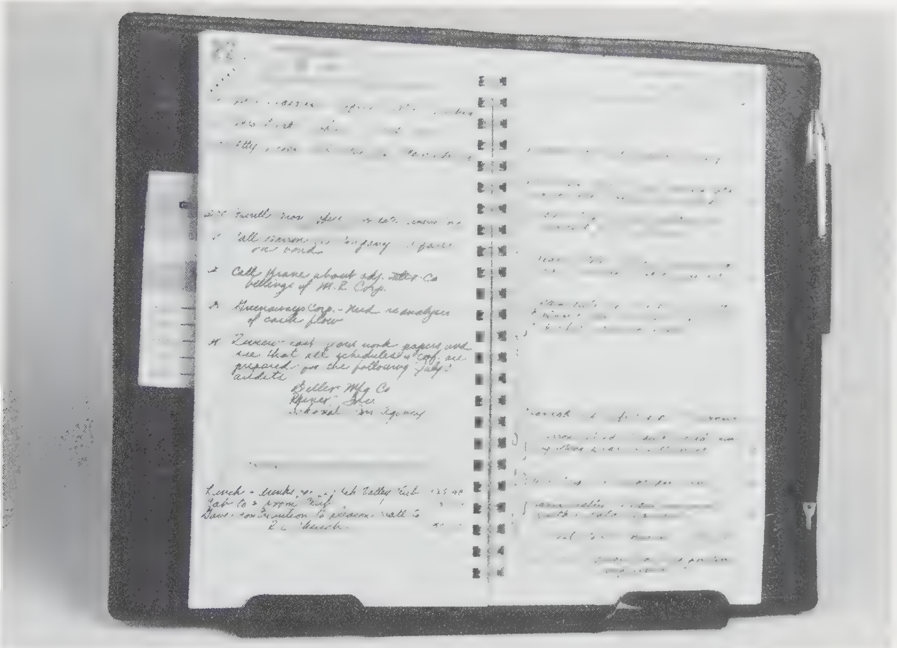

Figure 12.5 Examples of Day-Timers personal time management system. This particular "organizer" is known as the "2-Page-Per-Day Original Format." Adjacent pages provide space for: an appointment schedule with open hours, a list of things to be done today, a work diary with hours identified from 8 am to 6 pm, and an expense/reimbursement record. A full year is contained in 12 monthly books. (Day-Timers, Inc., Allentown, PA "Designers & Marketers of Time Management Systems")

Cellular telephones were introduced several years ago for prices well over $2500. Their price tags have dropped considerably making them more affordable among ordinary civilians. Car telephones pack a double hit of status in our society. Not only do they provide the veneer of busyness, but they also lend their owners the glamor of airline pilots embarked on exciting missions.

If some of these examples regarding the pace of life and the rate of technical change seem rather silly, perhaps it is because you are not yet wrapped up in the express track of competition. If they seem all too real and near to your heart, welcome to the end of the 20th century, an era of perpetual motion, and the death of permanence. In either case, your personal attitudes toward the stability of your routine and the relentless pulse of change are a lot less malleable (capable of being shaped or fashioned) than you might think.

SOCIAL ATTITUDES TOWARD CHANGING TECHNOLOGY

In the months following the nuclear reactor accident at Chernobyl and the disastrous explosion of the space shuttle Challenger, *U.S. News & World*

Report worked with the Cable News Network to conduct a survey of the American people. They found a vast majority of those questioned still believed science and technology do more harm than good for mankind. Their statistics revealed, however, the margin had fallen from 83 percent in the early 1980s to 72 percent at the time of their poll.[1] This suggests United States citizens continue to possess an optimistic attitude and want to believe tomorrow will be better than today. It appears that a national conscience has awakened. Much of the credit for this positive trend toward a renewed interest in making the future a better place should actually be given to technology. Printing presses, efficient rural delivery service, radio programs, and television news broadcasts via satellites have put nearly everyone in this country on the same informational level.

Social attitudes develop over time as one generation provides the fuel of experience and knowledge to drive the next one along. Attitudes are the product of the capacity to scrutinize events and the freedom to evaluate information. Information is the lifeblood of social progress. American citizens have access to more information now than at any other point in time. The freedom to produce information has led to an almost chaotic abundance of free ideas. Consider the following media facts and figures summarized by *Time* magazine in the mid-1980s:

> In the U.S., there are 9,144 newspapers, 941 commercial TV stations and 300 public TV stations. Every kind of subject, from sex to childbirth, from economics to how to build a house, from politics to gardening to baseball to Lyndon LaRouche, is printed and aired and ventilated. This almost preposterous tide of information and opinion is not censored or jammed. American book publishers offer some 50,000 titles every year.[2]

Information concerning the many benefits we are about to reap from the miracles of science and technology is plentiful indeed. Just as abundant are the reports about technology's faults and the calamities associated with its use. The mass media, both print and electronic, are the basic means through which all parties involved in technological transactions can secure a common data base. Social groups are constantly inundated with information and have, at least in this nation, the freedom to decide how to digest it all. The manner in which individuals make these types of decisions is influenced by whatever attitudes they possess with regard to "change" in general. Overall, it seems safe to conclude Americans, unlike other national communities, are not a fatalistic people. Most of us have at least a modicum (small portion) of faith in the idea that everything can change—all it takes is luck, individualism, freedom, and an energetic drive to move ahead. America is still a place where the play of human nature is allowed the greatest latitude to arbitrate or judge and/or develop its tools for progress.

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[1] Trafford, Abigail, et. al. Living dangerously. *U.S. News & World Report,* May 19, 1986, pp. 19-22.

[2] Morrow, Lance. Freedom first. *Time,* June 16, 1986, p. 26.

ATTITUDES AND VALUES

Social scientists define ATTITUDES as the general disposition to behave in particular ways toward specific objects or events. They define VALUES to be social standards considered worthwhile or desirable. The two concepts are interactive from the perspective that each has a great deal of influence over the directions of a nation's scientific and technological change. The following paragraphs describe a few of the social dispositions which seem to be prevalent in contemporary American culture. Each of the examples provides a reflection of a "techno-trend" or "scientific-shift" of sorts.

Any number of adjectives might be chosen to describe the general public's attitudes toward science and technology. A few you may have heard include: cheerful optimism, disenchantment, idealistic support, fearful skepticism, ambivalence, mild disillusionment, and so on. Although it often seems attitudes are shaped over many years of experience and are not usually all that flexible, the impact of recent events can not be ignored. Personal perceptions about certain technologies are heavily influenced by contemporary breakthroughs as well as catastrophies. It also takes dedicated interest and factual knowledge to formulate opinions about science and technology. In a study conducted a few years ago, the National Science Board discovered that:

1. The public has a high level of interest in science and technology, but a low level of knowledge with regard to these areas. Nearly half of all adults surveyed reported they were very interested in issues concerning new scientific discoveries and the use of new inventions and technologies. Given the strong emphasis on high-tech in our political dialogue, advertisements, and academic programs, a pattern of increasing public interest is not surprising. In contrast, less than 20 percent of the population surveyed classified themselves as being very well informed about public policy issues related to science and technology.
2. Generally speaking, the public expressed a high level of confidence in the scientific community in this country.
3. Americans are optimistic about the future accomplishments of science and technology. Citizens hold high expectations for scientific and technological solutions to many important problems.
4. Approximately one quarter of America's adult population was described as the "attentive public" by the National Science Board researchers. These individuals reported a high level of interest in science or technology developments, felt well informed about them, and indicated that they pursued a regular pattern of relevant information consumption (technical journals, science newsletters, public media and special documentaries).[3]

The expanding scope and global effects of science and technology have stimulated a great deal of attention toward the need for careful government regulation of scientific research. Through the 1980s, most government regulating agencies focused on the applications of selected technologies. The advent of disciplines requesting approval for the use of human subjects, experimentation with recombinant DNA, and the use of nuclear materials has called for the establishment of government policies relating directly to both basic and applied research. It is becoming ever more apparent the judicious use of this regulatory power demands a populace knowledgeable about the benefits and risks of scientific research and technological advancement. An individual's general level of understanding and awareness of technology is sometimes described as TECHNOLOGICAL LITERACY. The author suggests it is also related to a social concept labeled TECHNOLOGY ACCORDANCE. Both of these ideas are discussed in more detail later in this chapter.

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[3] Report of the National Science Board. *Science Indicators: The 1985 Report.* (U.S. Government Printing Office, Washington, D.C., 1985)

In broad terms, an extremely impressive majority of United States citizens feel both science and technology have made their lives healthier and easier. Most seem to expect future prosperity as a result of ongoing contributions from this nation's great R&D laboratories. Refer to Figure 12.6. Statistics also suggest there is widespread recognition among the public that science and technology simultaneously offer the promise of fulfillment along with the potential for destruction. Specifically, many persons presently express concern that the further development and possible deployment of nuclear, chemical and biological weapons might one day destroy the human race. See Figure 12.6.

An analysis of several other contemporary technological initiatives led the National Science Board to conclude that United States residents are quite capable of differentiating between those technologies which are "OK" versus those which should be curtailed. The table in Figure 12.7 presents data summarizing this social disposition. It is not surprising to learn public confidence in computer technology is significantly higher than its belief in the assets of nuclear power. This, after all, remains one of the chief sources of high-tech anxiety throughout the nation and around the world.

In sum, a growing proportion of the American adult population is becoming interested in scientific and technological events. There is an obvious prevalence of science and technology themes in feature films, television programs, and published fiction. Each of these reflects the scientific and technological profile of our current culture. The expanding numbers and rising sales of popular science magazines and of personal computers for use in the home seem to reflect the same characteristic. Prudent investors, brokers, and stock market analysts have become wise to keep abreast of "sci/tech R&D" in order to make money for themselves and keep their clients in the black.

Despite the technostress and the technophobia surrounding the lives of most individuals, there is still a dominant mood of optimism, although cautionary, in the United States. Perhaps this trait is deeply rooted in the general American character. As a people, we seem to be strongly supportive of science and technology. We believe much of the prosperity of the past few decades can be most directly attributed to the contributions of science and technology. For the time being, it is safe to conclude that contemporary American social groups will continue to look to science and technology to provide an improved, though always changing, quality of life.

PUBLIC PERCEPTIONS OF THE EFFECTS OF SCIENCE AND TECHNOLOGY: 1983

	Agree	No opinion	Disagree	N
	Percent			
Science is making our lives healthier, easier, and more comfortable. (Miller, 1983)	85	3	12	1,630
The future prosperity of the United States depends on more and better technology. (Cambridge Reports, 1983)	88	3	9	1,466
Most of the economic and social problems we face today as society will eventually be solved by technology. (Cambridge Reports, 1983)	58	8	34	1,466
Even if it brings no immediate benefits, scientific research, which advances the frontiers of knowledge, is a necessary human endeavor worth supporting. (Harris, 1983)	82	4	14	1,256
With the development of nuclear, chemical, and biological weapons, science and technology may end up destroying the human race. (Harris, 1983)	74	3	23	1,256
One trouble with science is that it makes our way of life change too fast. (Miller, 1983)	44	2	54	1,630
One of the bad effects of science is that it breaks down people's ideas of right and wrong. (Miller, 1983)	29	7	65	1,630

Figure 12.6 Chart which reports statistics regarding public perceptions of the effects of science and technology. (National Science Board)

PUBLIC EVALUATION OF RECENT TECHNOLOGICAL DEVELOPMENTS: 1983

Development	"Will make life better"	"Will make life worse"
	Percent	
Computer	88	9
Hand-held electronic calculator	87	8
Laser beam	76	13
Permanent space stations	70	14
Genetic engineering	67	16
Robots and automation	64	28
Nuclear power	48	44
N = 1,256		

Figure 12.7 Table which summarizes public evaluation of recent technological developments. (National Science Board)

RESPONSE MODES

Quality of life is an elusive concept which is not easy to define. One simple explanation for this principle suggests it is a balance between what people need and want, and the extent to which the environment can provide for them. Some of the typical quality of life indicators that sociologists and cultural anthropologists use to study this concept include: standard of living or per capita income; psychological/mental well-being; environmental stability/quality; general climatic conditions; opportunities for self-sufficiency; and so on. Technological pursuits serving to enhance or improve these general criteria are defined as both beneficial and progressive for society. On the other hand, technologies having the imminent potential to detract from, degrade, or destroy these criteria are defined as hazardous, risky, or detrimental to social well-being.

A number of examples have already been presented to illustrate situations where technology is either applauded for its contribution to the quality of our lives or blamed for the problems we face. The manner in which society responds to both the conveniences afforded and the problems caused by technology are commonly associated with: personal bias; preconceived notions or expectations; the amount of information available and the degree to which it is perceived to be accurate; personal interest in the issue; level of understanding and awareness; previous experience; and technology's general track record. Taking all of these factors into consideration, there appear to be a variety of behavioral responses used to confront the equivocal (uncertain or undecided) nature of technological change. Also known as RESPONSE MODES or coping behaviors, six of them are described here.

IMMEDIATE ACQUIESCENCE. This type of behavioral response to change is one where the individual verbalizes implicit trust in the experts. Although the "blind faith" attitude is rare, for some people it provides a measure of security with regard to a technology not easily understood. For others, it depicts an ingrained belief that the benefits of technology will always outweigh the costs. Public support of the space program during the 1960s was indicative of this perception and illustrated a form of this sanctioning behavior.

APATHY. Persons who cope with technological development in this manner do not want to be bothered with the "boring" or "gory" details. They typically express concerns about the amount of effort it takes to keep their daily routines in order. They don't have time to worry about whether or not genetic engineering experiments are being properly monitored. Denial is sometimes a part of apathetic behavior as well. For instance, we really don't have the power to destroy ourselves at the push of a button – "WarGames" and "Star Wars" are fictional portrayals of society created by Hollywood's tycoons.

RELUCTANT ACCEPTANCE. When people go along with changes for fear of what might happen to them if they don't, they exhibit a response mode called reluctant acceptance or approval. In many cases, this is an interim behavior providing only a slim vote of confidence in the proposed or pending technology change. It is a common attitude held by those people for whom the "scientific jury is still out." This response allows persons to cope with the early stages of change by enabling them to sit back and observe the effects of a new technology without going on record with any distinct opinions. While often doubtful of the benefits, this attitude is one of "interested ambivalence." Current public perceptions about the future of our space program might fall into this category.

AVOIDANCE. This response mode best illustrates an individual's inability or unwillingness to cope with changes created by science and technology. Personal emotions such as fear and anxiety often play a role here and may result in avoidance. Persons who respond with avoidance make some sort of a decisive action which results in an observable, structural change in their lifestyle. They may decide to change jobs, leave the area, withdraw from a university, or even commit suicide in order to avoid the situation. For this segment of society, the risks associated with technology are perceived to be dominant over any benefits. This response mode may also be predicated on ethics and the moral aspects of pursuing a particular technology. A scientist's decision to leave a laboratory that he/she learned was constructing nuclear weapons in order to conduct basic research at a university might fall into this behavioral category.

REACTIONIST REJECTION. This strategy to cope with technological changes and scientific proposals is the one which receives the greatest amount of media coverage. Persons who rely on this response are willing to openly protest the technologies they oppose. Operating on emotional "gut" reaction, they are not afraid of the legal consequences for their actions. They may sabotage the observable artifacts of the technology. These individuals appear to focus primarily on the detrimental side effects of technology while losing sight of any potential benefits. Many of the rallies and lobbying efforts against nuclear reactors and weapons laboratories are best classified as reactionist rejections of technology. Figure 12.8 portrays an avid group of peace activists during the later years of the Vietnam War—a period in our history when this particular response mode was far more prevalent.

ACCORD. The response mode most of us would like to think we use to confront new technologies is labeled accord. It literally implies agreement and harmony. However, the behavior patterns used to describe accord go much further. People who either accept and approve, or reject and disapprove a technological proposal in this mode do so with a lot of thought. Their decisions and actions are based on understanding, awareness, accurate data and information, logic, and common sense. It takes more time to reach accord because all the pros and cons are weighed before an attitude is portrayed. The person who takes time to research an issue like toxic waste management before voting on a clean water initiative is using this behavior to cope with change or to actually stimulate it.

Each of us has, at one time or another, used one or more of these six behaviors to deal with a crisis or cope with changes in our lives. Not one can

Figure 12.8 Persons who actively demonstrated against the Vietnam War and protested the draft were often photographed in this behavioral response mode of reactionist rejection. (Spartan Daily Newspaper, San Jose State University)

be identified as "the best" or "the most common" for all situations. Social response to science and technology is usually a reflection of perceived control, literacy, and independence. Each of these social traits has something to do with society's persistent "love affair" with its technology.

TECHNOLOGY TRAPS

If we stop and take a good look at the network of technologies which sustain our daily routines, it is hard to deny our dependence on them. This is not to say reliance on technical systems is a bad thing, it's just reality. Some people openly admit their need to surround themselves with technology's warm blanket of conveniences. Others feel trapped by it.

In a literal sense, the word "trap" refers to confinement or imprisonment where escape is either very difficult or near impossible. Life in our contemporary society is replete (filled) with traps associated with technology. Just about every moving vehicle might be construed as a technology trap of sorts (e.g., automobiles, airplanes, bullet trains, submarines, subway trains, elevator cars, etc.). Can you think of others? Each time we step into one of these vehicles and watch the doors close behind us, we take the risk of not being able to escape its confinement. While most people do not stop and think about that possibility when they get into their cars or step onto an elevator, many do feel that way when they board an airplane. In each of these transportation modes, users routinely illustrate their dependence on technology to get them to their final destination—quickly and safely.

There are many other situations which can be cited to provide a *literal* translation for the technology trap principle. Modern hospitals and their impressive surgery facilities reveal our reliance on technology to cure illnesses and save lives. A person who is "hooked up" to a life support system certainly must experience the sense of being confined or trapped. Engineers who work inside government laboratories requiring them to pass through a series of security checks may also feel trapped by technology. Coal miners who descend to work in caverns that are located many feet under the earth's surface are definitely aware of their dependence on technology to get them back out at the end of their shift. Identifying physical technology traps is not difficult once you start the creative juices flowing.

On a more *abstract* level, a technology trap is defined as much more than physical confinement. It is yet another profile characteristic of our modern society. The technology trap concept refers to man's DEPENDENCE on any technological system or device he either *does not understand* OR *can not control*. More often than not, we tend to utilize or maintain technology in such a way that we look like we know what we are doing. Behind the facade, quite often lies a vast amount of ignorance, inexperience, confusion, or even frustration regarding the technology that is being used. Technological systems and devices have advanced to such a state that they are regularly marketed as being "user friendly." What this means is that a person can use the device or monitor the system without possessing highly technical credentials. Today's automobiles are considerably more complicated than the ones manufactured in the 1930s. They are, however, much easier to operate. Contemporary automobile users do not need to be expert mechanics to drive their vehicles to work—those who expected to drive the earlier models did not have the same luxury.

Abstract cases of technology traps exist all around you. For instance, unless you are an expert software engineer, the chances are pretty good you do not fully understand why or how your word processing software works the way it does. As long as your term paper is submitted on time, why be concerned with its programming language? We also flip switches and press buttons throughout the day in order to execute a series of tasks. It is rare for most of us to stop and wonder about even the location let alone the internal mechanisms of the power station providing the electricity we effortlessly use.

We casually pour all sorts of detergents into the water used to wash our clothing. The number of individuals who truly understand the chemical formulation of those products and why they work the way they do is quite small. Consider also the hourly worker at a chemical plant employed to monitor a number of gauges in the company's central control center. Let's say this person was instructed to engage switch "A" if the needle in gauge #201 reaches a certain measurement, or switch "B" if the reading on gauge #417 falls below 43 °C. Unless the operator truly comprehends the outcome of these actions or the reasons they are being performed, the control panel may be considered a technology trap.

None of the examples mentioned is intended to make you feel inadequate or hopeless about the manner in which you depend on technology or make use of it without a second thought. They are simply and innocently presented to get you thinking about the kinds of ordinary instances wherein each and every one of us is dependent on the artifacts of modern technology. Some technology educators believe these activities have something to do with one's level of technological literacy. This concept was mentioned briefly in the DATELINE segment of this chapter.

TECHNOLOGICAL LITERACY

Literacy has been a topic of concern in educational literature for decades. At all levels of instruction, teachers have tried a variety of motivational techniques to enable their students to become literate. In the broadest terms, literacy presupposes the ability to read and write. If an individual is literate, he or she is generally thought to be educated and well-informed. This generic term has been teamed up with several modifiers in recent years. We hear stories about adult literacy, literacy among minority ethnic groups, computer literacy, technical literacy, and even nutritional literacy. Over the last decade or so, technology educators have espoused the need to design and implement curricular activities to improve our students' performance in the international "technological literacy" competition.

Technological literacy is an educational objective with widespread repercussions throughout the entire academic system. It is also an individual quest toward a meaningful existence in today's society. It is rapidly becoming a desirable managerial trait. The saying, "one doesn't need to understand the technology in order to manage it," is finally being disputed.

What makes a person technologically literate? Is there a standardized test one should take to determine his/her level of technological literacy? Responses to these inquiries are obviously contingent on the definition one accepts for this term. Although no one definition for such a comprehensive topic is "perfect," the following one is proposed for your consideration. TECHNOLOGICAL LITERACY involves an above average level of:

1. Knowledge of technical and scientific constructs and terminology.
2. Awareness of the impact (both negative and positive) science and technology can have on society.
3. Confidence and skill in the use of technology's tools, machines, and devices.
4. Control over the operation and functions of technical equipment.
5. Insight into the potential future states of specific technologies in order to project their social impact.

Wow! This is some definition! The astute reader probably noted the use of the phrase “above average level.” This presents a problem of interpretation. One must ask for clarification as to the meaning of average. What is considered average for one culture or social group may be either above average or below average for another group. Likewise, what is considered average for one scientific or technical discipline may not be true for other areas of study. With these facts on the table, it is safe to say everyone is technologically literate. It is equally truthful to conclude that no one possesses this quality. This debate could go on forever!

Defining a socially relevant term like technological literacy is always a challenge. Measuring the extent to which a person or social group has acquired a prescribed level of technological literacy is impossible. Certain elements of this lengthy definition can be assessed, but the data recovered are heavily influenced by self-examination activities. The National Science Board found a significant measure of disparity between the number of adults who indicated an interest in technology and those who felt well-informed (literate) about technology issues. See Figure 12.9.

PUBLIC INTEREST IN POLICY ISSUES VS.
ITS PERCEPTION OF KNOWLEDGE ABOUT THOSE ISSUES

Public interest in selected policy issues: 1979-83

	All adults			College
Percent "very interested" in . . .	**1979**	**1981**	**1983**	**1983**
Economic issues and business conditions	35	54	57	33
New scientific discoveries	36	38	48	42
Use of new inventions and technologies	33	34	44	38
Energy policy	46	50	40	27
International and foreign policy	22	36	30	24
Space exploration	NA	26	29	33
N =	1,635	3,195	1,630	2,011

Public perception of its knowledge about selected policy issues: 1979-83

	All adults			College
Percent "very well informed" about . . .	**1979**	**1981**	**1983**	**1983**
Economic issues and business conditions	14	30	28	15
New scientific discoveries	10	13	14	12
Use of new inventions and technologies	10	11	14	10
Energy policy	18	24	19	13
International and foreign policy	9	18	14	10
Space exploration	NA	14	13	13
N =	1,635	3,195	1,630	2,011

Figure 12.9 Two tables presenting statistics regarding level of public interest in selected policy issues and public perceptions of its knowledge of selected policy issues. (National Science Board)

Studies of this nature serve to provide periodic reviews of cultural awareness of science and technology. They do not measure technological literacy, but, that is not their objective. Even if we can not quantify the population's scores on a technological literacy scale, it is enough to agree that such a construct exists. Any amount of attention or energy devoted to its enhancement will not be futile given our dependence on technology.

RECOGNITION OF SOCIAL DEPENDENCY ON TECHNOLOGY

A series of titles have been proposed to describe this period in contemporary history. It has been labeled the information age, telecommunications age, post-industrial age, computer age and the biotech age. Regardless of the descriptive term one endorses, we are living in an age of technological enthusiasm laced with fantasy. It has been thrust upon us by everyone from Hollywood producers to government officials. The stunning record of technical accomplishment in this century lends support to their visions. For many citizens around the world, technology has become an article of almost religious faith. Today's technology is uniquely seductive since it appears to offer viable solutions to some of this planet's biggest problems. In some ways, it further encourages us to abdicate our personal responsibilities for these problems.

Social glorification of technology took off over a century ago with its cascade of curious inventions including: the steam engine, electric lights, farm machinery, the domestic sewing machine, and even running water. We next witnessed the arrival of the automobile, the telephone, radio, television, jet aircraft, miracle drugs, and nuclear energy. Along the way, a manufacturing and marketing infrastructure provided the necessary avenues which led to technology's penetration into all segments of society all around the globe.

Technology was revered during the second World War for its potential to become the great equalizer on the battlefield. It helped the United States to purchase victory for its allies via its superiority in industrial production and sophisticated weapons. Following the Soviet space surprise in the late 1950s (Sputnik, 1957), the United States adopted science and technology as its chosen vehicles to regain global superiority.

In the final decades of the 20th century, we are inextricably (unable to be freed) addicted to technology. It underpins every aspect of our existence on this planet. Our affinity for technology and love for the conveniences it offers have led to our taking much of it for granted. Take a moment to review the contemporary businessperson's typical working day. The individual under scrutiny: awakes to a radio alarm clock; switches off the electric blanket; dresses in imported clothing made of synthetic fibers; defrosts the frozen orange juice and microwaves some type of breakfast treat with electricity generated by a nuclear power plant; commutes to the office in a highly fashionable automobile while listening to high fidelity stereo or making a series of cellular telephone calls; travels up to the 26th floor by elevator just in time to receive an important phone call relayed by satellite from a time zone on the other side of the globe. These are just a few of the machines that sustain our lives. Their influence does not cease with the close of the work day. The same person looks forward to the weekend to play with a host of high-tech toys (VCRs, power tools, video games, ski lifts, luxury yachts, remote controlled model airplanes, etc.). This is the present.

The future outlook for technology is promising but will inevitably lead to an increased level of "social technohypnosis." In other words, more people will be caught up in the spell of technology. All of us are at least vaguely familiar with implants of electronic devices such as heart pacemakers. We will see an increasing use of these technologies to drive leg and arm muscles, to serve as implantable substitutes for hearing, and to monitor the metabolic reactions taking place inside the body. Some of the work being done in cryobiology (freezing tissue to store it indefinitely) will permit complex organs such as livers and kidneys to be retained in a frozen state until needed. This will certainly lead to an expanded use of organ transplants to save more lives in the near future.

The fascinating world of computer electronics promises to continue its trek toward dazzling our imagination. Electronic maps, displayed on a small screen inside a delivery vehicle or your personal automobile will reveal details of local streets and landmarks. They will also be programmed to suggest the best route to take to your final destination. First-generation systems already exist. Amateur photographers can look forward to electronic cameras that record photographs on magnetic disks instead of film. This feature will enable users to preview the photos on a television or computer screen in order to decide which ones to print. Affordable consumer models are projected to be on the market within the next five years. Bank credit cards are becoming "smart." They are being embedded with microchips to store checking, savings, and other financial balances, together with personal medical data and important telephone numbers. In the very near future, Visa U.S.A. plans to test a version that features a small screen and 10-digit keyboard on the back of the credit card to enter and view information. See Figure 12.10.

It was not that long ago that automated bank teller machines, personal computers, high-speed facsimile machines, and on-line data bases were figments of the technologist's imagination. When they first hit the market, they were luxuries. Today they are necessities. In the eyes of some, this type of technology has made the world increasingly incomprehensible. Computers now make loan decisions, diagnose disease, and represent a vital nerve center for the nation's defense system. The programs which guide these complex systems are the product of thousands of man-years of diligence—it is rare for one individual to fully comprehend their operation. We have become, in many ways, a world community that deals with abstractions and depends on the interpretation of wiggly marks on paper and digital pulses in machines. In an age of instant gratification, many young people are growing up with the belief that things "just happen" almost magically.

As with any romantic love affair, ours with technology has had its share of euphoric (feeling of elation or well-being) moments interspersed with

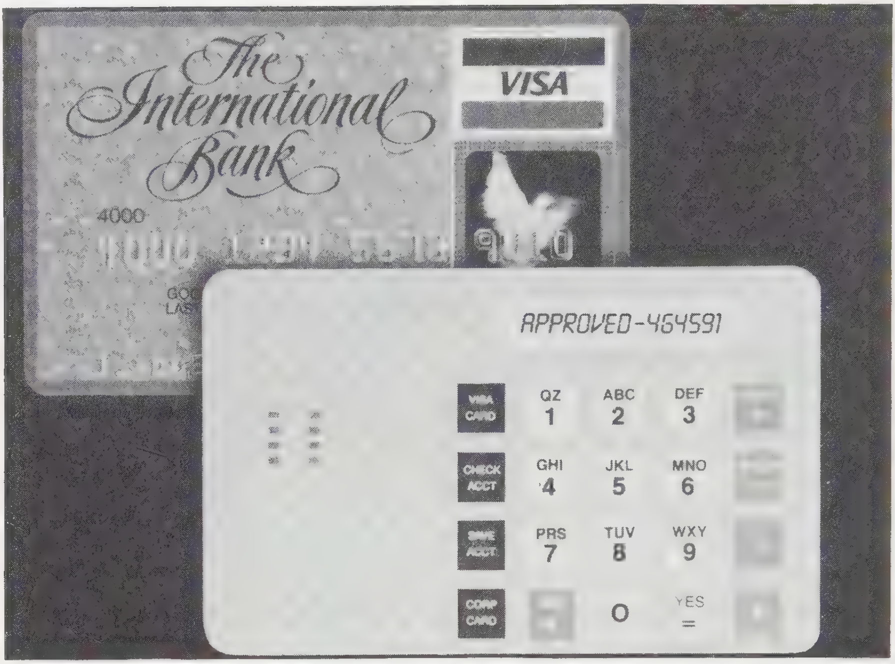

Figure 12.10 VISA "Super Smart" Card is the credit/payment card of the future. With a computer chip and a calculator-like keyboard, this card will allow consumers to instantly tap into their checking, savings, credit, or other accounts by simply pressing the appropriate button. The card will authorize transactions within itself, immediately update account balances, convert currencies, and even tell the time of day. (VISA U.S.A.)

periodic states of deep depression. The highs and lows are tempered by repeated cycles of reality testing. The ingenious achievements scientists and technologists have made in recent years represent an expression of mankind's finest creative instincts. Society is dependent on the fruits of its technology. Society also has the capacity to direct and control its technology to meet specific goals and objectives. It is the social management of technology which will ultimately determine the extent to which contemporary civilizations can access its benefits without sacrificing their values and cultural ideals.

LIVING WITH TECHNOLOGY = MAKING TRADEOFFS

Now and then, physicians have been known to remind their patients "any pill strong enough to help you is also strong enough to hurt you." This warning, of sorts, seems to be most applicable to many of the technologies discussed throughout this chapter. Our modern society is further characterized by a concept labeled **universalism** which refers to a global technology community. For example, a powerful electromagnetic pulse sent through the atmosphere by an adversarial superpower's defense system could knock out this nation's entire electrical power source in just a few minutes. This, of course, would totally immobilize us. Nevertheless, modern civilizations have become hostage to the forces of technological progress. There is no turning back because the benefits, both real and imagined, are enormous. The impending deficits are likewise greater than before and might turn out to be disastrous in the absence of a clear and prudent plan that provides for a "fallback" system of survival.

RISK-BENEFIT ANALYSIS

A couple decades ago, risk analysis was an obscure concept. Throughout the late 1970s and into the 1980s, it became a major growth industry. Around the world, businesses, utilities, labor unions, insurance companies, hospitals, and government agencies are seeking the services of risk assessors. These institutions are requesting assistance in estimating and controlling risks from toxic chemicals, accidents, and other hazards. Some of these requests are a direct result of regulatory legislation. Regardless of the context, the risks assessor's central question usually boils down to safety—"How safe is safe enough?"

The proliferation of technologies has expanded the scope of risk at an exponential rate. A century ago, if a maintenance worker failed to attach a carriage wheel properly, the lives of half-a-dozen people were threatened. In this day and age, when a manufacturer fails to install an O-ring properly in an L-1011 aircraft, more than 300 lives are at stake. The potential for disaster in mass transit, mass production and mass destruction has grown geometrically. As our world becomes more interactive and centralized, the easier it is to sabotage its technological life support systems. Our very survival on this planet depends on the personnel who tend the military computers and keep them running properly 24 hours each day. At any moment, it seems the lives of millions are at the mercy of a few individuals who are just as human as we are. What if they make a mistake? Many of us deal with our fears of being powerless by placing our faith in the competence of the people or the technology in control.

We ask what went wrong when presented with the dark side of technologies at risk. A partial list might include the following milestones along our precarious road toward progress: Bhopal, Chernobyl, Love Canal, Tylenol, AIDS, toxic shock syndrome, Challenger, asbestos, acid rain, PCBs, cancer, Agent Orange, and so on. These examples imply we are living in an "age of risk." But, the human race has always lived at risk. How we react to and deal with risks may have changed, but we must continue to live with the sober truth there is no such thing as zero risk. Perhaps it is man's realization of this caveat (warning) which motivates him to press forward in the quest for greater safety while simultaneously creating newer technologies against which we must be protected. While these hallmarks of civilization seem to contradict each other, somehow we manage to keep the motors of social improvement running at full speed.

If one accepts the fact that safety is the absence of risk but that risk can not be totally abolished, a method to determine an acceptable threshold level must be derived. Safety, expressed in terms of acceptable risk, is a social judgement call. Investigating the "how safe is safe" issue necessitates two central considerations. First, from a technical perspective, what are the probabilities of occurrence and the possible severity of harm? And secondly, from a social perspective, what sorts of cultural and ethical norms are established with respect to the valuation of a single human life, personal property, or the natural environment? Stated in a different way, the technical experts often worry about the quantity of the risk while the general public worries about the quality of the risk.

This leads into the question of disparities between perceived risk and actual risk. When the experts assess the risk of a technology, they are primarily concerned with how many people die from it in an average year. When lay persons evaluate the risks of technology, they focus on a much broader list of criteria, such as: How well do we understand the risk? Could it wipe out an entire community? Will it make a particular area uninhabitable for a long period of time? Might it affect future generations or some members of society more than others? In answering each of these sensitive questions, experts offer the public a series of numbers and estimates to put technological risks into perspective, while public perceptions warn them against using sheer statistics to assess risks.

We assume the experts know a great deal about the technical aspects of nuclear power, space flight, food additives and pesticides. This enables them to calculate very narrow definitions of risk in terms of factors which can be reduced to numbers and then extrapolated to make probability statements. For instance, one Air Force report estimated that the chances of a fatal accident on the space shuttle were 1 in 35 – compared with 1 in 10,000 for a nuclear disaster or a dam failure. When people read probability statistics, they are often less interested in the numbers and more anxious about whether a hazard is new or old, known or unknown, controllable or uncontrollable, voluntary or involuntary, and the degree to which it is potentially catastrophic. Fear of nuclear radiation is punctuated by each of these perceived threats.

Even though more people die in automobile accidents each year than have perished in accidents related to nuclear power, the public views nuclear accidents as being much more frightening. Much of this anxiety is due to a dreaded fear of the unknown. The risks of a nuclear accident are seen as unknown, uncontrollable, and most likely catastrophic. When persons can not be certain about the risks they are forced to confront, they at least want to have some measure of control over the activities and technologies that produce them. Much to the chagrin of risk analysts, people tend to be more willing to accept higher risks in activities over which they have control like driving, smoking, skiing, and drinking. They approve much lower risk thresholds for activities where they have little control such as industrial pollution, food additives, genetic engineering, and commercial airlines. It is intriguing to review the differences between expert opinions and public perceptions regarding the risks of various activities and technologies. See Figure 12.11.

In order for society to judge "how safe is safe enough," there must be a widespread level of technology awareness. It is difficult to evaluate the potential for danger or disaster if one does not know what the risks are. Ostensibly, the purpose of government regulation of technology is to protect the public from a wide range of technological hazards. In other words, they have the

PUBLIC PERCEPTIONS VS. EXPERT OPINIONS REGARDING RISKS ASSOCIATED WITH VARIOUS ACTIVITIES AND TECHNOLOGIES

Do your worries match those of experts? Paul Slovic, President of Decision Research found significant differences among three different groups surveyed. Orderings are based on the geometric main risk ratings within each group. Rank 1 represents the most risky activity or technology.

Activity or technology	**League of Women Voters**	**College students**	**Experts**
Nuclear power	1	1	20
Motor vehicles	2	5	1
Handguns	3	2	4
Smoking	4	3	2
Motorcycles	5	6	6
Alcoholic beverages	6	7	3
General (private) aviation	7	15	12
Police work	8	8	17
Pesticides	9	4	8
Surgery	10	11	5
Fire fighting	11	10	18
Large construction	12	14	13
Hunting	13	18	23
Spray cans	14	13	26
Mounting climbing	15	22	29
Bicycles	16	24	15
Commercial aviation	17	16	16
Electric power (non-nuclear)	18	19	9
Swimming	19	30	10
Contraceptives	20	9	11
Skiing	21	25	30
X-rays	22	17	7
High school and college football	23	26	27
Railroads	24	23	19
Food preservatives	25	12	14
Food coloring	26	20	21
Power mowers	27	28	28
Prescription antibiotics	28	21	24
Home appliances	29	27	22
Vaccinations	30	29	25

Figure 12.11 Table to compare public perceptions regarding risks of various activities and technologies with expert opinions. (Paul Slovic, Decision Research)

obligation to manage risk. Legislative initiatives over the past years have been enacted in an attempt to: reduce uncertainty and surprise; enhance the visibility of possible cause-effect relationships; anticipate immediate and future impacts; and illuminate the alternatives that might spur prevention and delegate responsibility to all parties involved. Somewhere along the way, the word "tradeoff" was invented to describe the process of deciding whether or not society has the dexterity or ability to contain the side-effects of its technological feats.

TECHNOLOGY ACCORDANCE

In the end, it appears that science and technology are both good and bad, but they are never neutral. Samuel Florman referred to this state of reality as a "tragic view of technology." He believes that people must be aware of the dangers without foolish illusions about what can be accomplished. He has little respect for those individuals who enjoy the benefits of technology but refuse to accept the responsibility for its consequences.

Technological change is unavoidable. The method in which society chooses to manage it and respond to it is, however, quite flexible. TECHNOLOGY ACCORDANCE is a label used by the author to refer to the extent to which a social group is able to recognize and take advantage of the potential benefits of a technological breakthrough and simultaneously control its negative side-effects and risks. At the root of accordance, we find one of the response modes identified earlier — Accord. As a greater proportion of society selects this coping behavior to decide the fates of new technologies, civilization will be a giant step closer to long-term sustenance.

SUMMARY

Change is perhaps the only constant! Although society has convinced itself most changes are *revolutionary*, it is far safer to suggest changes tend to be *evolutionary*. This further implies people should take the time to stop and reflect on the changes taking place right now in order to chart a course of active living for the future. This chapter examined the concept of social change from several points of view. Science and technology were defined from two perspectives: (1) Science and technology change our lives on a regular basis; and (2) We, the people, routinely demand new science and technology to meet our changing expectations. In the first view of reality, society lags behind technological change, whereas in the second technology is perceived to lag behind social needs.

In order to cope with new and demanding scientific and technological breakthroughs, social groups rely on a number of behavioral response modes. Of the six presented in this chapter, "accord" is the one that seems to be most energy efficient. It is characterized by attentiveness to the risky side effects of technology, coupled with well-informed decision making regarding the exploitation of its benefits. A technologically advanced civilization must also be technologically conscious in order to preserve its survival. Technological change is linear but it is not devoid of cyclic patterns of regression. Sustained progress mandates the design of "fall-back" systems to protect us against our sciences and technologies that just might fail.

DISCUSSION QUESTIONS

1. Explain the reason the word "change" elicits emotional reactions from many persons. What phrases are often used to "tone down" the use of the word change in various social settings?
2. Differentiate between the concepts labeled "system overload" and "information overload." Provide contemporary examples to illustrate the similarities and differences between them.
3. How does the social need for instant gratification erode the busyness syndrome? How does it also help to sustain it?
4. Why do you think the American public continues to retain its belief that science and technology make our lives healthier and easier? What types of situations might persuade people to disagree with this assertion?
5. Identify and describe the six behavioral response modes to illustrate the ways we cope with change. Provide your own examples that symbolize each behavior.
6. Define what is meant by the term "technology trap." Provide several examples to illustrate its literal meaning as well as its abstract connotation.
7. If you were required to prepare a report responding to the question "How safe is safe enough?" with regard to an outdoor genetic engineering experiment, what type of information and data would you attempt to secure? Who would you rely on for expert advice and recommendations during the course of this exercise?

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Chapter 13

THE STABILITY OF TRADITIONAL SOCIAL INSTITUTIONS

DATELINE

San Jose, California

A disturbing phenomenon seems to be evolving in this city and numerous other metropolitan centers: The disappearance of the traditional family dinner. Social scientists report the days of gathering around a huge dining room table for meals, on a somewhat regular basis, may be gone forever in this country. Instead of eating three squares (or even one oblong) with members of our families, we are eating out, taking out, ordering in, and munching on the run. And yes, there is a name for this frenzied dietary regimen—it is called "grazing."

For decades, the evening family meal represented a time when children and parents could bridge the gap of their respective days. Eating at the table in the privacy of one's own home is one of the primary ways in which growing children learn about the conventional behaviors they will need to be in touch with as adults. Mealtime is a time when values are taught, social graces are mastered, and children learn to communicate and express their feelings. Many of us seem to be forgoing this opportunity to teach and learn in order to have time for aerobics classes, jogging, pick-up basketball, television, and dieting. It also seems spending time together is becoming less and less important than being busy.

Campbell Soup, together with other food companies, is actively responding to the demands of a culture preferring to graze rather than dine. Among the new products in the grocery store are individually frozen broccoli spears, preplated soup frozen in a disposable bowl, and microwavable, frozen (low calorie) gourmet dinners. Campbell is reportedly working on the formula for soup in bar form—sort of like granola . . . .

INTRODUCTION

Social institutions are the structural mainstay of civilization. Throughout history, human beings around the globe recognized the need to establish a variety of social settings in order to most efficiently conduct the business of life. Beyond their ability to order "living" patterns, these social institutions provided a sense of hope and security as well as a means for survival. People have a tendency to associate specific roles and responsibilities with each of the social institutions existing in their communities. Formal institutions provide the order and organization for a culture to sustain itself. Cultural anthropologists conduct systematic and scientific studies of the typical behavior patterns of persons residing in each of the world's continents. A contemporary concern among these researchers is the extent to which modern technology may be influencing the stability and shape of traditional cultural mores and customs.

It is always difficult to formulate a precise definition for a generic concept. Since social institutions are the primary focus of this chapter's discussion, it would be very helpful to understand what they are! In all probability, most of you already have a clear sense of what these terms mean. You could easily provide a list of examples evident in your hometown community to highlight your explanation. In fact, before reading on any further, take a moment to write down a few of the social institutions you believe to be currently operative in your life right now. For the purpose of our discussion, a SOCIAL INSTITUTION refers to a formal entity existing primarily to nurture and contain certain behavior patterns considered to be important in society. If one chooses to use either the word "traditional" or "contemporary" as a descriptive modifier, this explanation should still remain adequate.

Getting back to the initial question, what are some of the social institutions we depend on to structure the manner in which we conduct our daily routines? If the list you just compiled includes such items as family, church, school and government, you have identified four of the most commonly accepted social institutions throughout the world. These formal groups are readily viewed and categorized as "traditional" since they have been so widely respected for centuries. Some cultures revere their sanctity and believe in the importance of their preservation for the good of all mankind.

In recent years, a series of equally formalized, but far less conventional, groups have evolved in our society. If your list identifies health clubs, corporate offices, research laboratories, and singles bars as social institutions, your perspective is significantly more modern. Although none of these entities has earned the level of recognition afforded to religion and education, they are just as important to many career-minded individuals in today's social milieu (setting or environment). In the eyes of some researchers, the corporate office has achieved a higher position on the list of personal priorities than the family living room. Fast and furious, individualized exercise programs have become a substitute for community involvement and civic duties. Refer to Figure 13.1.

Figure 13.1 Exercising to music in the form of well-structured aerobic fitness classes has become quite popular across the country. Individuals who pursue this type of exercise program recognize the benefits of a complete body workout and cardiovascular health. Some health clubs offer these classes throughout the day, but it seems to be the evening (dinner hour) classes such as the one shown here that enjoy the greatest attendance among the membership. (Paul Wright, Courtesy Decathlon Club)

Computer software advancements continue to threaten the integrity of "real live" teachers. Computers themselves seem to be influencing our religious beliefs. The corporate gymnasium has become a setting where powerful political decisions are often heatedly debated and finally settled.

Are the traditional social institutions we have relied on for years currently being replaced with a host of alternatives? Furthermore, is modern technology having an adverse effect on their stability? Some researchers respond affirmatively to both inquiries. They seem convinced technology is the driving force behind the introduction of these new colored threads into the tapestry we call our society. This chapter provides a synthesis of some of their opinions and theories as they relate to both traditional and contemporary social settings. Although it is not possible to provide a thorough analysis of all the institutions mentioned so far, the following areas will be discussed in some detail: family life, religious attitudes, educational programs, and recreation activities. These four topics are selected to depict a cross-section of "contemporary" social activities and the persistence of "traditional" social institutions in a world of technological change.

1. Is the traditional nuclear family becoming an endangered species in present-day society? What sorts of social groups do you think will come together to act as surrogate families?
2. How has technology affected the way women structure their lives? Further, what sorts of influence has modern technology had on the socialization of the children of these women?
3. What impact have science and technology had on the importance of religion in America? Are computers changing our image of God?
4. Why are some educators and school administrators fearful of implementing new technologies into the classroom curricula? How can they cope with the anxieties brought on by unfamiliar technologies?
5. In what ways has technological change affected the manner in which we spend our leisure time? What sorts of "high-tech" developments have changed the profile of the recreation industry?

KEY CONCEPTS

As you study the ideas presented in this chapter, try to develop a persuasive definition for each of the following concepts as it relates to a cultural analysis of technology in society.

Socialization
Creationism
Parental Leave
Social Institution
Computer Assisted Instruction (CAI)
Nuclear Family
"Zipping" & "Zapping"
Expert System

THE FAMILY: TECHNOLOGY & PERSONAL RELATIONSHIPS

In today's fast-paced world of technological and social change, most persons still seem to be spending their lives in families, couples or looking for compatible partners. In the 1980's, according to the Bureau of the Census, more than 60 percent of the United States population was married, approximately 7 percent was widowed, nearly 6 percent was divorced, and 25 percent was single. For those satisfied with singlehood, the task of establishing friendships and alternative relationships (sometimes called surrogate families) is evident in contemporary social settings. Varying levels of intimacy are evident within these personal involvements.

Men and women have expressed various forms of reverence for the institutions of marriage and the family throughout most of history. These age-old social institutions have been applauded and often referred to as the lifeblood of a society. With specific regard for the family, we are presently fearful of its projected demise. Some people are resistant to change in its accepted structure, but remain willing to propose modifications in it to adapt to changing social circumstances. Economists commonly refer to the family as the fundamental unit of society. Some economists also claim to be able to assess the well being of the whole nation on the basis of what they perceive as the family's state of health. The traditionally accepted functions served by the family unit in civilization include the following:

1. It is a provider of love and emotional support for its members.
2. It is the principal agent of socialization for children.
3. It is a primary source of economic support.

In a recent investigation of American social attitudes toward the family, the following statement about children's literature is found:

> Families in books for children are always nuclear families. Only rarely does the extended family live in the same household and rarely does it live nearby. The extended family, nonetheless, is frequently mentioned and is held in respect. Families in these books usually include school age but not infant children. . .Infants, frail old people, and the handicapped, all characterized by heavy dependency needs, appear only recently—after 1950—in children's books. Problems of uncomfortable relationships between parents, of separation and divorce, of sibling rivalry and fighting are discussed only in the most recent books.[1]

While it is true literary works do not *exactly* mirror social changes and/or realities, they often provide a great deal of insight into the prevalent attitudes regarding socialization. The same thing can be said for television's portrayal of social institutions including the nuclear family. The families made for television usually bear some resemblance to reality but also contain their share of highly imaginative and idealistic features. In real life, most fathers do not *constantly* behave like "Bill Cosby" and most siblings do not interact with each other like the members of "The Brady Bunch!" Nevertheless, these and similar television programs certainly illustrate the types of expectations we, as a society, have with regard to our "family ties."

The profile of the contemporary family unit is quite a bit different than it was only three decades ago. A recent national study revealed the traditional image of the nuclear family, consisting of a working husband and his stay-at-home wife with two or more dependent children, now accounts for less than 10 percent of all American households.[2] It is projected the subsequent weakening of religious, social, and legal directives will foster the growth of a variety of household arrangements including: heterosexual cohabitation, single-person households, unwed single-parent families, and homosexual couples. In three decades since the mid-1950s, the number of single person households in this country expanded from 10 percent to 25 percent of the nation's total. While some expect this percentage to rise even more in the upcoming years, the social institution of marriage will continue to remain fashionable.

Individuals' reasons for marriage in the mid-1980s seem quite similar to those mentioned in the past: love, commitment to growth as a couple, security, social approval, and a desire for greater intimacy. Companionship represents a slightly revised variation on the older themes; both men and women have found they can be self-sufficient but still have a desire for the closeness of a committed relationship. Another contemporary reason for marriage, generally expressed by both sexes, is a growing disillusionment with the "singles rat race" and concern for physical health. The outbreak of the disease acquired immune deficiency syndrome (AIDS) has had an unequivocal impact on the interpersonal relationships between men and women. "Casual sex" is no longer commonplace in the early stages of a couple's interaction. Also apparent, the frenetic pace of work in a technologically progressive society does not leave a person with a whole lot of energy and/or ingenuity to go out and search for companionship at the end of the day. In this scenario, the comfort and quietude of a marriage seem quite appealing.

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[1] Mary Lystad. *At home in America: As seen through its books for children.* Cambridge, Massachusetts: Schenkman Publishing Company, Inc., 1984, p. 137.

[2] R. Morton Darrow. *The state of families 1984-85.* Family Service America, 44 East 23rd Street, New York, N.Y. 10010.

A previous perception of marriage commonly viewed the family as a business enterprise of sorts: The husband earned money and provided for the woman. In return, the wife agreed to do the housework and bear children. Persons who decide to get married these days are bringing a whole handful of new expectations into the marital contract. Pre-nuptial agreements have become more the rule than the exception in recent years. Today's partners seem to be more aware of the need for their marriages to involve other dimensions in order to be both fulfilling and successful. Women expect to be included in financial matters. Men expect to have direct involvement in the nurturing of their infant children. Not all persons expect their marriages to be permanent, but most enter into the union intent on making it work.

Despite the changes taking place in family living arrangements, shared activities are still considered to be very important. Even though the family dinner may not be scheduled every night of the week, this activity is generally regarded as a significant, central time for all members (see DATELINE). There is a move toward the "quality of time" spent with family to compensate for the reduced quantity. In other words, the family dinner table may not be on its way out, but actually experiencing a rebirth in some households. Families who *plan* to have dinner together at least once a week may find them to be a genuinely rewarding endeavor.

Without question, there has been a social revolution in family lifestyles over the past two decades. The extent to which technological changes (either inside or outside the home) have been a driving force behind this revolution is still somewhat vague. There are those who suggest that industrialization and technology have torn the family unit apart. Others predict the advent of telecommuting as a work mode will draw families closer together. Some social observers insist this new method of "going to work" is straining traditional family roles and causing household conflicts. Continued advancements in household technology will stimulate further evaluation of men's and women's roles on the homefront. For some persons, life in today's technological world is too complicated and often scary. This phenomenon may ultimately cause contemporary families to pull closer together to make it through the hard times. Undeniably, the "essence of family" will survive as an important source of stability well into the foreseeable future.

MODERN CHILDHOOD

Since today's engineers, scientists, technologists, and marketing specialists are all determined to make it to the top of their respective career ladders, it is not uncommon for them to lament about how difficult it is to be a parent. Instead of worrying about polio vaccines, pneumonia, and ear infections, today's parents find themselves worrying about drugs, teenage pregnancy, and nuclear annihilation. If the truth be told, their children are probably having just as much difficulty trying to be kids! In some ways, there appears to be an overall merging of childhood and adulthood happening in our culture. Children who are growing up now are undergoing a host of psychological and social pressures. Too many children are being forced to grow up too quickly.

During the first half of the 20th century, childhood was generally considered to be a time of innocence, amusement, and isolation. It was a time for young people to be sheltered from the demands and alarming realities of adult life. Kids were dressed differently than adults and each group had its own language. Certain words and topics like birth, death, sex, and money problems were treated as "off limits" for children's ears. Schools were structured within a strict age-grading system which designated what a child of a given age should know and be able to do.

As the shape of family units has undergone change, the last three decades have also witnessed a remarkable change in the image and characteristics of children. See Figure 13.2. Childhood is no longer viewed as a protected and sheltered period of life. Today's children seem less "childlike" in a number of ways. They speak more like adults, dress more like adults and behave more like adults than they did 10 to 20 years ago. The so-called "magic years of youth" do not always seem to be so magical anymore. Children are trying to cope with a world in which both parents are working, sex and drug abuse have permeated the elementary school yard, and graphic violence is commonplace on the television screen. Mimicking adult behaviors, more children than ever before experiment with alcohol and other drugs at an earlier age, sometimes under 10 years old.

Some of the stresses contemporary kids are confronting are being inadvertently inflicted by their overly status-conscious parents. Many of the pressures on children are directly related to America's new and novel lifestyles. Day care programs provide one example. Current statistics show almost 7 million children nationwide are cared for in family day-care homes or in child-care centers. Child psychologists seem to be in agreement that sending children who are under three years old to day care is more stressful for the kids than staying at home with a parent or a familiar babysitter. The child must comply with the environment—the daily program does not always respond to every child's individual needs or expectations.

There seems to be a growing concern that overworked parents will most likely beget harried children. Today's children have a higher degree of concern about time and meeting deadlines than those raised in an earlier, less hectic

Figure 13.2 Numerous video game issues have arisen over the past 10-15 years with respect to their addictive nature. Proponents of this form of youth activity suggest video games can stimulate attention, exercise memory and reaction time, and develop fine motor skills, especially eye-hand coordination. Less enthusiastic are individuals who believe video-game addiction among youths causes them to skip school and waste a significant amount of money on the machines. Regardless of whether video games are a fad or the forerunner to a technological playground, they seem to mesmerize youth (and some adults as well). The extent to which any components of this techno-toyland are applicable to learning has yet to become an accepted fact among contemporary educators. (Michael Dafferner)

period. Unlike previous generations, many children's daily routines are usually dictated by mom and dad's workload. Their schedules for meals, bedtime, television privileges, and baths are no longer predictable. It is unlikely the intermittent parcels of ersatz (substitute or artificial) "quality time" parents devote to their young ones can adequately compensate for a lack of "quantity time."

Modern childhood is plagued with a much greater amount of fear. Kids these days face a dangerous world out there. The milk carton on the breakfast table is plastered with pictures of missing children. The evening news is filled with stories of kidnappings. It is no longer clear what topics should or should not be discussed with children. In any event, children now seem to know about previously forbidden topics well before they are spoken about in their homes or school education. Birth control, abortion, alcoholism, and suicide have become children's issues in recent years.

A larger percentage of young children also seem to be expressing their fears of a nuclear holocaust. Discussions centering on this topic commonly evoke feelings of confusion and helplessness. Adolescents seem to know there is something vastly dangerous and threatening in their world. However, very few have any real understanding of the technological information about that threat. One wonders how many of the problems today's youths are facing are actually tied to the underlying menace of nuclear war. Consciously or unconsciously, children know their future lives can be obliterated at any moment by the flick of a switch or a glitch in some computer chip located in some distant underground military command center. Perhaps the main reason today's kids are having difficulty working toward long-term goals is due to their lack of confidence in their own futures. It may be true the age of innocence is shorter than ever before, but all hope is not lost.

Parents and educators alike can do a lot to minimize stress on kids and reduce their fears about technology and violence. Children need to be raised with a strong realization there *are* many problems in the neighborhood, the nation and the world. And, they are growing up with the capabilities to help solve those problems. Instead of nameless fear, adolescent students need to begin experiencing a sense of their own power as citizens with a responsibility to help eradicate serious social dilemmas.

Parents need to communicate more with their children and learn to respect each child's individuality. The recent emphasis on fierce competition and getting ahead has typically gotten out of hand. Preadolescents should not be pushed so much that they lose sight of the importance of cooperation, helpfulness, and good old-fashioned love in their daily adventures. We may eventually come full circle as a result of the problems our young people are encountering. The traditional family unit may find itself back in style with the next decade or two. A recent *U.S. News & World Report* cover story revealed an interesting change of pace and direction in this country. It seems a small number of parents (who can afford to) are starting to reassess whether or not the stresses of two-income families are really worth it. Which of the two partners do you suppose will choose to return to "man" the homefront if this trend takes hold?

WOMEN'S ROLES: CHANGE VS. CONSTANCY

Any discussion attempting to evaluate the stability of the family unit in our society would be considered deficient if it neglected to address the changing roles and responsibilities among women. Since the "women's movements" gained national momentum during the early-to-mid-20th century, numerous essayists, historians, and social scientists have published on a wide assortment of topics. Some universities also offer baccalaureate degree programs bearing the title "Women's Studies." Several prominent areas of discourse include: women's rights; equality in the work place; entrance into the labor force; recognition in the non-traditional fields of science, engineering and technology; the development of household technologies; use of reproduction technologies; and so forth. If one makes a diligent effort to sift through all of the material, one very general conclusion can be derived. While women's roles have changed dramatically during the past several decades, many roles have also remained constant.

Household Technologies

In some circles, there is a commonly held belief that technology developed for the home can "free" women to participate in other non-housework tasks. This might be true if the technology could actually change the way in which household maintenance tasks are divided among the family members who reside there. Regardless of whether or not they hold a wage-earning position, the practice in North American homes today is still for women to do the largest proportion of these tasks. One study concluded the total time spent on housework either increased or remained constant between 1930 and the 1950s. Technology itself has *not* reassigned more tasks to other members of the household and it has *not* reduced the routine demands placed on women.

Utilities such as running water, electricity, gas, telephone, garbage service, and waste water with sewage treatment plants represent the technological infrastructure in the home. These technologies probably changed the nature of household work more than other technical improvements since they eliminated a series of burdensome tasks. On another level though, utilities such as gas and electricity may have fostered other technological changes by facilitating the introduction of many in-house appliances of all shapes and sizes.

Amazing as it might sound, recent studies discovered that a large portion of these so-called "labor saving" devices actually make tasks more difficult instead of easier!! Cleaning some electrical kitchen appliances often takes more time than executing the task manually. Two examples are the food processor and the noisy electric can opener. See Figure 13.3. Appliance repair has become more difficult and mysterious. The service charge to fix some appliances often costs as much as replacing them with new models. As household machinery becomes more specialized, the difficulty of understanding either the mechanical or the electrical operation has increased. Further, it often appears this computerized and electrified equipment is designed with planned obsolescence in order to sustain demand for new sales.

While technological innovations may have lessened the physical effort of housework, they have not significantly reduced the amount of time involved in keeping up with it. The presence of technological gadgets and devices in the home has not lowered the psychic burdens on women. Nor has the presence of technology changed the allocation of labor by gender. In fact, the greatest impacts on the manner in which contemporary housework is conducted emanate from nontechnological changes. Specifically, the pressures of inflation along with the desire for additional goods and services have drawn women into wage-earning positions, households are smaller and women are becoming less anxious about having their homes "spotless" and constantly ready to pass the "white glove test."

Reproduction Technologies

Birth control technology has played a critical role in stimulating and fueling women's movements throughout the 20th century. In earlier decades, barrier methods of birth control helped change the primary role of women as

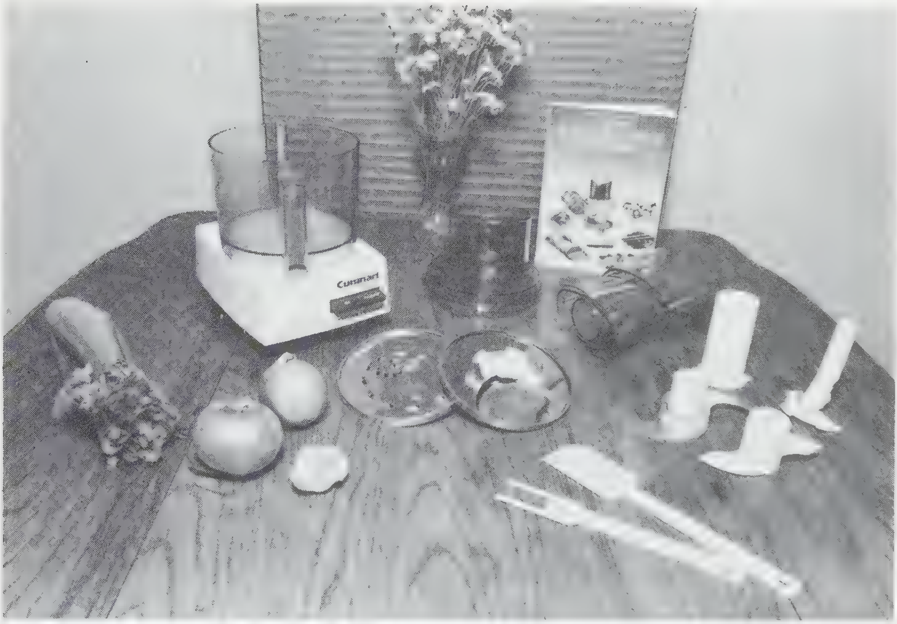

Figure 13.3 Food processors were introduced into the American kitchen over a decade ago as an exciting labor saving technology. The above photo depicts a typical model that consists of: a base housing the motor, a work bowl sitting on top of the base, and a series of discs and blades designed to chop, slice, grate, puree, shred, grind, and knead a wide assortment of foods. Since all of the individual components must be cleaned separately, its labor-saving profile is best observed when large quantities of ingredients must be prepared. (Michael Dafferner)

mothers and culminated with the passage of suffrage for women (1920). The later introduction and dissemination of the pill and a variety of intra-uterine devices (IUDs) further increased the ability of women to control procreation. These methods were more effective and much more convenient to use than previous solutions. More so than technological changes in the home, birth control developments led to the greatly increased rate of labor force participation among women.

Improved, safer, and more reliable birth control technologies will continue to increase the amount of control women have over their own bodies. Women can now control both the total number and the timing of the children they bear. Birth control has been a catalyst for a number of social changes making the quest for long-term, intimate relationships for both males and females somewhat easier. On the other hand, many of the changes associated with their searches have made the maintenance of long-term relationships much more difficult. Even though birth control technology has altered and expanded the number and type of relationships available to men and women, most persons still seem to desire a long-term commitment at some point.

Reproduction technologies have increased the control women have over childbearing, but they have not eliminated the necessity for it. For those couples wishing to have children and perpetuate their family name, modern birth control usually makes it possible to achieve the desired number and spacing of children. It further enables the woman to simultaneously pursue other career objectives. However, the ability to delay childbearing via birth control devices does not always result in the desired ideal family. Some couples who postpone childbirth decisions experience fertility problems. New technologies to correct infertility are still being tested but are becoming increasingly available.

The more important dilemma of who will rear the children remains. There is no "technological fix" for this responsibility. Not all duties associated with child care can be purchased – regardless of how affluent the couple is in our society. Kids are not robots and they require a lot of parental attention and interaction for their mental and emotional stability.

"The Family and Medical Leave Act" is designed to allow parents of newborn or adopted children a federally mandated leave from work with complete job security and no loss of medical benefits for up to eighteen weeks. (Note the word "parents.") The United States is alone among industrialized nations not already guaranteeing such protection. Compared to Finland, which provides 35 weeks of leave at 100 percent pay to either the mother or the father, and to West Germany which offers mothers fourteen to eighteen weeks of pay within a total leave of 26 weeks, eighteen weeks without pay seems rather paltry. In any event, the concept of "parental" vs. "maternal" leave says something about the changing views regarding the family unit as a viable social institution in our modern world.

THE CHURCH: TECHNOLOGY & RELIGION

For centuries, persons from all ethnic and educational backgrounds as well as all socioeconomic levels have looked (and continue to look) to their religious institutions for comfort and guidance during times of sorrow or confusion. Because of modern technology, it may be possible that some are changing their traditional views of "church," or their definitions of God and other beliefs. As modern technology and science continue to provide cures for previously incurable illnesses, some may feel they no longer need a Supreme Being who is all-knowing and everlasting.

This and various other reasons have led some sociologists to suggest that modern technology functions as a type of religion for some who have abandoned belief in God. At the same time, there are religious leaders who believe that modern technology is causing a resurgence of humanity's quest for religion. There are no simple explanations for why the proliferation of scientific fact and technological know-how would lead one person to question the existence of God while it would lead another to even greater belief in a deity.

Many of the prevailing religious and ethical issues of the day are rooted in the world of scientific experimentation and technological innovation. The dilemmas of euthanasia, the wonderment associated with genetic engineering, the mixed blessings of atomic energy, and the medical technologies of procreation are all legacies of a contemporary techno-scientific culture. One noteworthy response to these and other contributions offered by technologists was recently delivered by Vatican officials. In a document entitled "Instruction on Respect for Human Life in Its Origin and on the Dignity of Procreation—Replies to Certain Questions of the Day," the Vatican asks governments around the world to ban "artificial procreation," including sperm banks, embryo banks, post-mortem insemination, and surrogate motherhood. It also recommends laws against embryo research and abortion. These new strictures represent one of its most expansive public statements since the encyclical on birth control released in the late 1960s. See Figure 13.4.

These concerns about the impact of technology on procreation stem from the Catholic Church's view that human life is sacred from the instant of conception. A belief in that idea commands further opposition to *in vitro* procedures producing spare embryos be used later for research or destroyed. Similarly, prenatal testing, also called genetic counselling, giving parents the chance to abort an abnormal fetus must be considered forbidden. The Vatican insists any technology separating the act of conception from the conjugal act is morally wrong. It is difficult to fully describe widespread public reaction to this ecumenical treatise. As with previous discussions regarding science, technology, and religion, the initial discourse may seem rhetorical. In other words, various groups will make elaborate attempts to describe a complex social issue which eludes specific characterization.

In its condemnation of artificial conception for infertile couples, the Vatican document is heavily reliant upon its earlier restrictions against contraception. In the same way that contraceptives separate sexual union from procreation, the church argues in vitro fertilization techniques separate procreation from sexual union. Many Catholics do not agree with their church's opposition to birth control. It follows they may also be inclined to question its latest directive. In fact, some theological observers believe the Vatican's response to the technology of fertility may cause its present congregations to disregard some of its other teachings. On the other hand, society may ultimately view this document as a timely warning against a growing scientific indifference to the origin and vulnerability of human life.

THE DEBATE BETWEEN SCIENCE AND RELIGION

It seems that whenever the word Christianity surfaces in the scientific press, its readers tend to prepare themselves for yet another round of "creationism" debate. Stated differently, spectators will expect the fundamentalist Christians to insist upon the validity of Genesis and refute any scientific diatribes concerning the evolution of the human species. Indeed, there are a number of variations on the creationist theme, and each group is trying to reconcile Genesis with science in some particular manner. There are also many Christian scientists who regard the creationism debate as irrelevant to the essence of contem-

PROCREATION POLICY ESTABLISHED BY VATICAN CONGREGATION FOR THE DOCTRINE OF THE FAITH

Highlights of the Vatican document

The Vatican document on artificial procreation expresses moral opposition to the following practices:

- Prenatal diagnosis, including the use of amniocentesis and ultrasonic techniques, for the purpose of eliminating fetuses that are affected by malformations or that are carriers of hereditary illnesses.
- Surrogate motherhood.
- Any artificial fertilization involving persons who are not married.

- Test-tube fertilization and embryo transfer involving a married couple.
- The artificial insemination of an unmarried woman or of a widow even if the sperm was donated by her husband.
- The collection of sperm through masturbation.

- Therapeutic interventions and methods of observation of an embryo that involve disproportionate risk to its health.
- All experimentation on living embryos not directly therapeutic.
- The keeping alive of human embryos for experimental or commercial purposes.

- Utilization of dead fetuses for commercial purposes and unnecessary mutilation of dead human embryos and fetuses.
- The voluntary destruction of human embryos obtained in vitro either for purposes of research or of procreation.
- Biological or genetic manipulation of embryos through practices like fertilization between human and animal gametes and gestation in the uterus of animals or an artificial womb.

- Efforts to obtain a human being without any connection with sexuality through methods like "twin fission," cloning, or parthenogenesis.
- The freezing of an embryo even when done to preserve its life.
- Efforts to influence chromosomic or genetic inheritance that are not therapeutic but which aim at producing human beings selected according to sex or other predetermined qualities.

The document expresses moral approval of the following practices:

- Prenatal diagnosis, including the use of ultrasonic techniques and amniocentesis, that aims at safeguarding or healing the embryo.
- Prenatal therapeutic efforts designed to heal an embryo of maladies including chromosomal defects.

- Prenatal research limited to the simple observation of an embryo.
- The use of experimental therapy on an embryo as a final effort to save its life.
- Artificial insemination within marriage when the technical means is not a substitute for the conjugal act but serves to help it achieve procreation.

- Fertility drugs.
- Medical interventions that facilitate the performance of the conjugal act.
- Medical intervention to remedy the causes of infertility.

Excerpted from the Vatican document entitled "Instruction on Respect for Human Life in its Origin and on the Dignity of Procreation—Replies to Certain Questions of the Day" (San Jose Mercury News)

Figure 13.4 Chart which summarizes highlights of the Vatican statement regarding procreation and technology.

porary science policy. Their basic tenet is that faith needs science and science needs a firm grounding in western religious heritage. Both parties seem to have a great deal to gain from one another if the primary objective is a deeper humanization of science, technology and society.

Today's scientists should be reluctant to live out their scientific lives in a research laboratory devoid of any spiritual foundation. Likewise, religious leaders who aspire to have a voice in determining the future uses of technical information and technology in general should have at least a rudimentary understanding of the scientific method. At the core of the debate between science and religion, it appears that:

1. Scientists believe religion skews objective reasoning, fuels repressive movements, and stifles freedom of thought.
2. Religious leaders are convinced science pursued from an agnostic or atheistic base will continue to feed the ever growing materialism in society and contribute to the violence of the modern age.

Fortunately, there seems to be an emergent group of humanists who support the goals and convictions of both camps. Although they may differentiate science from religion as two distinctly separate areas of human life, they also identify ways in which the two share common points of contact in our society.

One example of a commonality is related to mankind's relentless quest for understanding and intelligibility. Many believe the essence of science is experimentation which produces data observable to the senses. Empirical methods of research usually yield empirical data. But, the true objective of scientific inquiry is not the generation of data but the attainment of intelligibility. Scientists search for patterns which isolate relationships between one bit of sensory data and another. These patterns constitute an understanding of reality rather than an unrefined list of facts and figures.

Understanding science as the search for intelligibility suggests science and religion share the same ultimate goal. Namely, they both envision the capacity to provide tangible meaning to the world and human existence. Theologians do not use empirical methods with a great amount of scientific rigor. Theologians do seek to make our unique human experiences significantly more lucid. They routinely attempt to provide answers to questions like: What is the destiny of humanity? Why do innocent people need to suffer? Reporters once asked Albert Einstein what he thought about the existence of God. He replied that he thought it obvious that there was an intelligent force in nature that put the universe in organized motion. He had no problem with science and God residing in the same space.

Both religion and science provide ways of obtaining intelligibility in contemporary society. Neither institution can speak with absolute precision. Both are constantly trying to use language to demystify realities often beyond the capacity of language to explain. Many of us look to religion for personal guidance, support, a sense of belonging, and hope for the future. At the same time, we look to science and technology for an enhanced quality of life, a sense of progress, and hope for the future. Religion does not try to explain nature the way science does. Science, with all of its limitations, can not give intelligibility to all of what we experience as human beings.

COMPUTERS AND GOD'S IMAGES

The traditional view of God deeply integrated into our culture is inherited from Judeo-Christianity. Specifically, God is "out there," enduring beyond time and space in a state of permanency not susceptible to change. God is the creator of all that exists. God is the unifying force which allows the continuation of life as we know it. God determines and represents the nucleus of life after death. And so on.

Social scientists are beginning to speculate whether computer technology will have a far-reaching impact on these traditional images we have of God as our creator who is all-knowing and all-powerful. For instance, computers have become integrally involved with the medical field. They appear to be changing and improving the manner in which we are able to procreate human life. Is the view of God as the one who creates, nurtures, and sustains human life rendered less precise when humans and their machines are allowed to interfere with the process?

On another front, through the aid of computers, the general population is able to tap into vast resources of knowledge from their own homes and offices. The average citizen living in the industrialized world of the late 20th century has access to a immense bank of information. Pre-computer scholars were known to spend their entire academic careers in the pursuit of wisdom now available to the common man. Perhaps an omniscient God does not seem as awesome to the individual who can find out a great deal through a directed, computerized search of the literature. Instant communication on a global scale via computer technology might also change our perceptions of omnipresence. Corporate executives in Chicago who are engaged in a "real time" videoconference with engineers in Bangkok may feel they are in some ways approaching being "everywhere at once."

Further, the field of artificial intelligence seems to be developing such refined ways of emulating human reasoning that it may not always be possible to distinguish between humans and machines. We are bombarded with interactive programs to diagnose diseases and make suggestions regarding ways we can improve our sense of self esteem. Will persons who have difficulty differentiating between minds and machines have just as much trouble seeing the difference between humans and God? Avowedly, this last inquiry is rhetorical, but intriguing just the same.

Computers in our world may truly be changing our traditional views of God. To suggest computers have the power to either replace God or even diminish a person's religious beliefs seems fatuous. In fact, astute computer scientists would probably be the group least likely to make this sort of testimonial. They are quite in touch with the reality that a modern computer capable of processing the amount of information stored in the human brain would need to be about ten thousand times larger in volume than the human brain! From this vantage point, computer technology provides a new mode of comparison without affecting our traditional images of God. Computers are our newest and most sophisticated "tools" to make further attempts to comprehend the true meaning of life and human existence.

THE SCHOOL: TECHNOLOGY & EDUCATION

The days of the little red schoolhouse lovingly constructed on the prairies of this great nation seem like ancient history as we approach the final decade of the 20th century. Nevertheless, the stalwart school building has retained its role as one of the most influential social institutions we encounter throughout childhood, adolescence, and early adulthood. The profile of the curriculum and the salient (prominent) features of the building and its classrooms are different but the primary objective is alive and well. Schools exist to educate and socialize the residents of a community, state, nation, or continent. Schools house the industry we call education. Their productivity is measured via the success of the students who traverse their hallways and learning centers. Is technological advancement threatening the stability of this traditional social institution? Are the fruits of technology impacting the educational delivery systems destined for use in an ever-changing world?

Educational commissions, task forces and ad hoc committees regularly issue reports which warn us about the demise of this country's educational system. These editorials indicate the quality, value, and relevance of a major segment of our educational services has been declining over the past several years. The assumption that *more* education is beneficial for individual students and the nation as a whole is no longer justifiable. Projections of this nature have made it clear this nation's future leaders will be "at risk" unless more attention is devoted to our schools.

A major responsibility of schools is to prepare students to enter a rapidly changing job market and political environment. Schools are expected to mold students who are adaptable and able to respond quickly to the changing requirements of new technologies. Within the next decade, it is expected that workers' job descriptions and task definitions will change significantly every five to ten years. This means our schools will train both youths and adults. Adult workers will require additional education and retraining each time business and industrial operations are updated. Schools will continue to be commissioned to provide a greater number of services to the local community, to area businesses, and to young students. Educational institutions may become the primary mechanism to mitigate skills/knowledge obsolescence in a society where lifelong learning is the accepted norm.

TECHNOLOGY IN THE CLASSROOM

Education is one of just a handful of major American industries yet to be thoroughly computerized. Its turn is on the visible horizon as computer hardware manufacturers and software developers are starting to eye education as their next big gold mine. An intriguing assortment of high-tech wares already exists for classroom teachers. Products in the form of microcomputers, software packages, data bases, interactive electronic media, and far reaching telecommunications linkages all cost money. Since educational decision-makers feel that they have been "burned" before with investments that failed to pay off, it is understandable some still remain reluctant to adopt all of the latest technologies making their way from industry to the schoolhouse steps. Obtaining classroom equipment is certainly an integral part of curriculum development and/or modification, but it should not be the first step. The two most essential questions prospective buyers should ask are: Will the new technology improve productivity and quality in teaching and learning? Is the technology relevant to specific instructional goals?

In an attempt to address these crucial inquiries, one southern California school district decided to develop a logical approach to both the acquisition and utilization of new technologies in their schools. The first phase of their technology plan commenced at the onset of a school year with the opening of what they labeled the "Classroom of the Future." See Figure 13.5. This center was designed to serve as a prototype for new and remodeled classrooms in the district. It also facilitates an active partnership with private industry to augment the information resources available to the educational staff. Professional liaisons between education and industry provided valuable learning ventures for students and faculty alike.

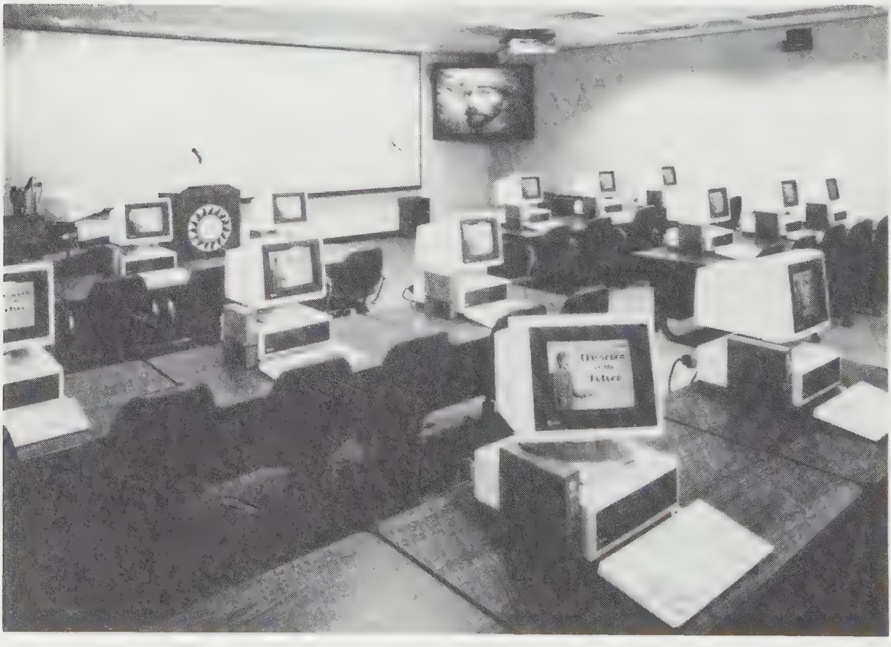

Figure 13.5 "Classroom of the Future." (Placentia Unified School District)

This model "Classroom of the Future" is regarded as a laboratory for the training of teachers, administrators, and support staff members. When persons have the opportunity to familiarize themselves with new-fangled technologies on neutral territory, they are less likely to fear its full scale implementation at a later point in time. The technology center is place where new hardware and software can be pre-tested before being adopted for use in the classroom. It allows educators to study new instructional techniques harnessing the power of several overlapping technologies including: satellite-delivered instructional programming, laser discs, interactive videodiscs, computers, videocassettes, and closed-circuit television. This future-focused classroom prototype also features a central work station from which the "teacher" can monitor all of these systems simultaneously. This technological scenario is a far cry from the traditional picture of a bespectacled professor who stands in front of the classroom lecturing to a group of pupils who take copious notes from the dusty old blackboard. It seems safe to conclude the primary role of today's teachers has already begun the transition from the dispensation of information to the facilitation of creative, analytical thinking among their students.

COMPUTER-AIDED INSTRUCTION (CAI)

Reduced costs and improved performance are two of the most compelling reasons for increasing the use of computers in instruction. In CAI, computers are used as supplements to conventional teacher-led instruction. CAI is now used over a wide range of subjects in most schools across the country. The price of microcomputers has fallen dramatically. Along the way, a tremendous surge in the development of educational software has occurred. Complementing the earlier drill-and-practice programs designed to supplement the teacher's presentation are a wide variety of software packages. See Figure 13.6. These instructional aids consist of "tool" software, "problem" software, and "simulation" software designed for use in courses like: programming, logic, music, graphics, and mathematics. It appears computer programming specialists are intent on demonstrating their adeptness at devising "expert systems" for use in our schools. Generally referenced in the field of artificial intelligence (AI), an expert system for educational use is a computer program which condenses a huge amount of accumulated knowledge on a given subject into a form of question-and-answer routine to lead the learner through a logical progression to the correct response.

While software improvements are being made regularly, some professionals believe the resultant learning modules will soon replace some kinds of textbooks. Software can be tailored to meet individual student needs and can be updated more efficiently and inexpensively than textbooks. Computers can also be linked with videodiscs to provide sight, sound, and movement. These features promise to provide a new dimension to lessons in history, art, political science, and the like. The one drawback to this form of delivery system is that younger students may have a tendency to "view" these lessons as they would a television program. In other words, less studious learners may not absorb a lot of the information presented.

As microcomputers and educational software become increasingly available in contemporary classrooms, teachers are finding it necessary to figure out how to best manage these resources. The first step toward effective management is to view the computer as a tool. The acronym CAI itself implies instruction is "aided" rather than "crafted" by the computer. School systems should avoid purchasing a large number of microcomputers simply because they represent the wave of the future. It is senseless to set up a classy new computer lab only to find later it is either underutilized or not used at all for want of trained personnel, good software, maintenance, or secure facilities.

Educators who approach CAI with specific problems in mind, and then ask how the computer can be used as a tool to solve them, are more likely to synthesize sensible and successful applications for their computers. For instance, it may not be necessary to house a large number of computers in the classroom. Strategic planning may reveal a ratio of one computer station per five or ten students is adequate. In selecting software for the class, the teacher must be careful to identify those units that will ultimately promote the effective use of the computer as a tool to meet his or her curricular objectives. It is especially critical to develop a management strategy that can facilitate the smooth rotation and recycling of students through the CAI package.

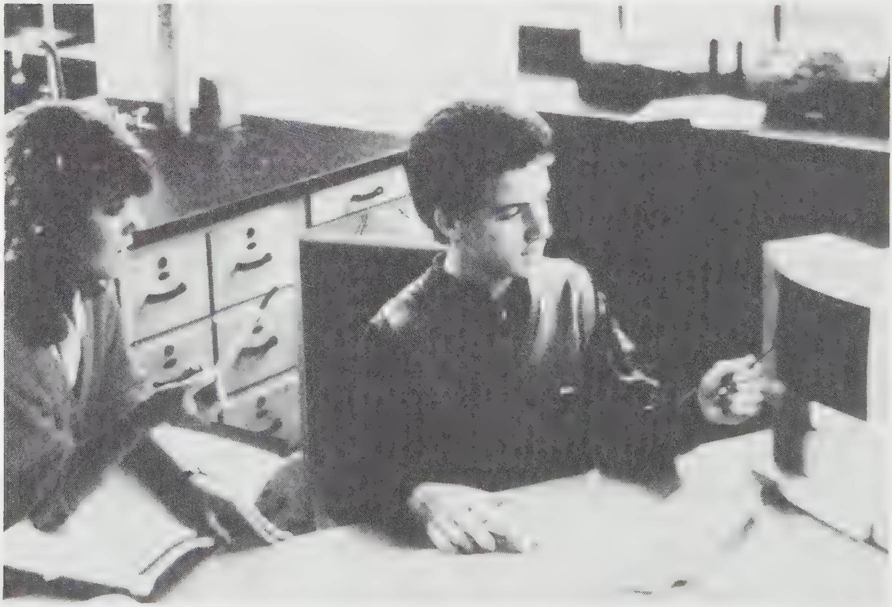

Figure 13.6 The presence of personal computers in elementary and secondary classrooms has become more and more common over the past decade. These high school science students are using one of the many software packages designed for use on the Apple personal computer. (Apple Computer, Inc.)

In the rush to join the computer revolution, school district administrators should not lose sight of the importance of careful evaluation and planning. CAI is just one of many instructional approaches. The cost-effectiveness of CAI should be assessed through the extent to which it can provide instruction more efficiently than other alternatives. Computers and education have become inextricably linked. Parents worry about whether their children are "computer literate." Educators fret about tracking the latest trends in technology for the classroom. And, students are anxious to gain experience with computers in order to launch a successful career.

Perhaps we have reached a point where we should re-examine our educational priorities and directions. Technology can either enhance our educational programs or undermine their long evident stability. Persons who profess to be educational leaders have an obligation to keep their curricular goals just as current as the technology-laden classrooms being designed to achieve them. In other words, the stability of educational institutions in our society will be more directly influenced by curricular relevance than by technical modernity.

THE PLAYGROUND: TECHNOLOGY & RECREATION

Few people would have difficulty accepting the fundamental fact that "play" is an essential part of the human condition. The concept of a "playground" however is usually more recognizable among the residents of the world's industrialized nations. Play is central in children's lives. Children make their world into a play-world at every possible opportunity. The urban movement, borne of the industrial revolution, has progressively and drastically reduced the opportunities for play. Busy streets pose serious hazards, vacant lots have disappeared, and high-rise living arrangements eliminate backyards. It is not surprising that the need to set aside special spaces where children could find at least a minimal opportunity for growth and development through play first became evident in the technology-oriented sector of the world. See Figure 13.7.

The playground movement in the United States was initiated during the late 19th century with the sandgardens in Boston. Its proponents asserted city life was ill-suited for the normal growth of children. Crowded cities stimulated a basic social concern for the provision of adequate play space for children. This became a catalyst to spearhead the formation of a new national organization. Around the turn of the century, the Playground Association of America was established to collect and distribute information concerning playgrounds and to promote interest in their development across the country. The provision of adequate open space for recreation has become one of several public policies which originated with and grew out of the early playground movement. Its primary advocate today is the National Recreation and Park Association (NRPA).

While not everyone envisions "recreation" or "playgrounds" as social institutions, few would deny the importance of leisure in contemporary society. Questions concerning how individuals spend their leisure time have led to new fields of study, formal degree programs, and a whole new technological

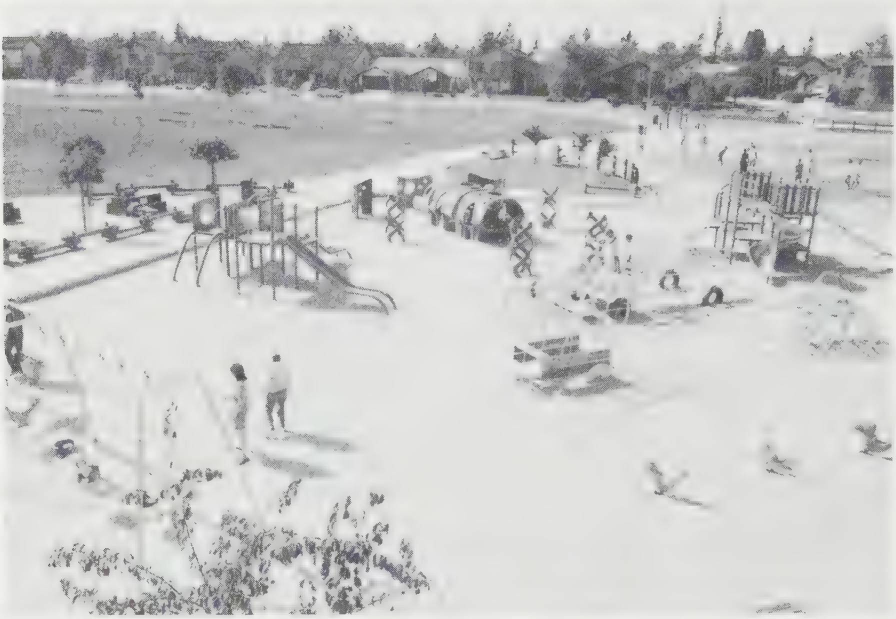

Figure 13.7 From sand gardens to ''high tech,'' we have witnessed dramatic changes in the design and construction of playground equipment during the past century. Playground manufacturers report the number one trend shaping the design of equipment is a concern for safety. There is also a growing demand for durability and an interest in the modular concept. While there are still many examples of traditional playground equipment such as swings, slides, and climbers in use, there is a trend away from purchasing one-use-only pieces. Recreational planners have the option of buying several components that can stand along or fit together to form a variety of shapes which serve to enhance and stimulate more creative play activity. (Michael Dafferner)

discipline devoted to "play-things." What does leisure look like in a technological era? It is unlikely the early playground pioneers, who initiated an organized response to a critical social concern, could ever have imagined the magnitude and diversity of organized recreation in today's society.

Throughout the 20th century, Americans have witnesses significant changes in their leisure patterns. In the early 1900s, workers put in, on the average, a 56-hour week. In recent decades, the average number of hours worked has coasted slowly downward. By the end of this century, the standard work week may be only 30 hours. A large portion of this reduction is linked directly to new technologies in factories. This translates to increased leisure time for employees. Technology has also influenced the types of leisure activities we enjoy. The term "sports" is the idiom used to describe some of the universal leisure past-times. Developments in technology have shaped the manner in which everyone, from the serious athlete to the hobbyist is able to participate in sports.

"Free time" is sometimes used to describe leisure. Nevertheless, the word leisure somehow conveys the idea the time is being used constructively. In some instances, it even implies the individual is engaged in upper class, "cultural" activities such as the ballet, opera, theatre, reading the classics, etc. When a person uses his or her free time to watch football on television while "slugging down" a few beverages with friends, the word "idleness" is sometimes substituted for leisure. This pejorative (degrading) expression indicates to some that the person is not doing anything worthwhile but is simply wasting the free time available. Of course, there are arguments for both definitions and neither leisure pattern is necessarily desireable for everyone. If anything definite can be said about our leisure time, it is individualistic. What some persons consider leisure, such as washing the car, others consider work. What other persons consider leisure, like televised football games, their friends may consider a boring waste of time! See Figure 13.8.

Besides giving us more time to enjoy leisure activities, our high-tech economy has also provided a number of new ways to use it, including electronic games, video cassette recorders (VCRs), affordable jet air travel, large-screen televisions housed in local neighborhood taverns, demolition derbies, recreational vehicles, and lots of high-tech athletic equipment. Of these, the most seductive leisure format is offered by the electronic media which absorb staggering amounts of free time in contemporary American households. Some writers have actually compared the television screen to the more traditional fireplace hearth. Analogous as they may seem, the latter example promotes conversation and romance while the former seems to stifle both.

Survey statistics indicate that watching television is perhaps the most common form of leisure today. The proliferation of VCRs during the 1980s provided the television viewing past-time with even more room to multiply. Television has been credited as the primary source of accessible news worthy information and as an educational tool to aid in the socialization of children. More often, television tends to be chastised as a technological intruder which has destroyed the personal interaction among family members and has stimulated the growth of violence in our society.

Regardless of the label ascribed to it, television demands very little from our minds and bodies. Its soporific (sleep inducing or mesmerizing) presence allows us to absorb as much or as little as we desire. The recent introduction of remote-control devices has made it possible to change channels, adjust volume, and advance the tape in the VCR without even getting out of the chair. As with other techno-gadgets, the remote-control feature has created two new terms associated with its use. "Zapping" refers to the practice of switching back and forth among channels, generally to avoid being exposed to product advertisements and commercial interruptions. "Zipping" describes the use of the remote-control buttons to fast-forward a pre-recorded tape to watch a one-hour show in about 53 minutes. This zipping strategy yields the same results as zapping—zero commercials. As you might well imagine, large corporations are becoming more reticent to spending huge sums of money on television ads

Figure 13.8 Adults devote time to their leisure activities for any number of reasons. Shown here are several examples of contemporary recreational settings: The therapeutic value of swimming, the competitive aspect of pick-up basketball, and the use of high-tech exercise equipment to stay in top physical shape. (Paul Wright: Courtesy Decathlon Club)

people "zip over" or "zap out" as they are being broadcast.

As an increasing number of Americans retreat to their electronic cocoons for their leisure, some appear to becoming psychologically dependent on the television set. Social scientists call them "vidiots" or persons whose free time is almost completely engrossed by video in its various forms. Meanwhile, another electronic device is starting to become more common in American homes. Even though the personal computer is much more intellectually demanding than the television, it still fits the electronic cocoon scenario of leisure patterns. As a type of leisure device, personal computers provide all sorts of electronic games. They also allow users to converse with other persons via bulletin boards and a systems network. Eventually, household computers may make it easier for us to do our shopping, banking, and even our work without ever leaving the house. Will this trend lead to the resurgence of the long lost delivery boy of the early 20th century?

In a previous section of this chapter, it was stated there appears to be an overall merging of childhood and adulthood in our society. As children try to act more like adults, adults often behave a lot like kids! This behavioral tendency is most obvious in the recreational interests among a growing population of young urban professionals (yes, the overused acronym "yuppie" is correct here!). An interesting social trend which not only supports this adult need for play, but also recognizes the importance of organized leisure activities, is the corporate recreational program. Listed under the discipline heading "Industrial Recreation," these programs are surfacing around the country.

EMPLOYEE RECREATION PROGRAMS

It is difficult to accurately pinpoint a time period when industrial recreation really got started. Perhaps the roots of this discipline can be found at the first company picnic given for the employees of Johnson Wax in Cincinnati, Ohio in the late 1800s. Or, maybe the catalyst was formed during an employee baseball game between the Equitable Life Assurance Company and the Metropolitan Fire Insurance Company in New York City in the mid-1800s. Some recreation professionals make reference to the World War II era when the nation called for increased productivity. The need arose to relieve the tensions of war and enhance employee unity in the midst of family separation and loss. In any case, employee recreation, services, and fitness (ERSF) programs have experienced tremendous growth in the United States over the past fifteen years.

With each passing fiscal year, the number of companies offering some type of recreation program as a component of their employee benefits package expands significantly. Corporations such as Chase Manhattan Bank, Mobil Oil, Exxon, International Paper Company, Chemical Bank, and Philip Morris have installed exercise facilities in their Manhattan offices. Many others have turned to private health spas and fitness centers as places for their employees to work out. In other words, while some firms have actually built an on-site facility, others have found it more convenient to purchase corporate memberships from nearby health clubs. Some of the predominant features offered by both types of programs are basketball, racquetball, tennis, weight lifting equipment, stationary bicycles, aerobics classes, and volleyball. Also available, on a less regular basis, are amenities like golf course access, company swimming pools, softball fields, and suntanning salons. The awareness of the importance of recreational facilities convenient for employees to use during the work day has spread beyond corporate executives. Concern for a holistic (emphasizing the functional relationship between the parts and the whole) business environment seems to prevail among forward-thinking architects and developers designing tomorrow's office and industrial "parks." In a bona fide attempt to attract corporate tenants, builders have included jogging trails, lakes, bicycle paths, fitness centers, and diversified landscaping in their plans.

If you study the construction documents for one of these industrial parks, you might wonder when anyone would find time to get any work done! On the contrary, since that first company picnic years ago, the philosophy has remained the same. Many executive officers firmly believe recreation services can cement employee loyalty to the company, reduce tensions, lower absenteeism, and promote employee camaraderie and morale. As you probably already guessed, numerous studies have been engineered to determine the validity of these sorts of convictions.

Most of the research results on this topic have been quite positive so far. It seems safe to conclude many important organizational advantages can be gained through employee recreation programs. For example, the National Aeronautics and Space Administration corroborated the findings of the Heart Disease and Stroke Control Program. They both recently concluded that a program of regular exercise reduced absences, improved stamina and work performance, and enhanced powers of concentration and decision-making. Along the way, they also found the average office worker's efficiency decreases 50 percent during the final two hours of the work day. By comparison, those who exercised on a daily basis were found to work at full efficiency all day long.

The most fascinating thing about recreational activities is their dichotomous (dividing into two parts) ability to either arouse and stimulate participants or relax them and calm their nerves. Essentially, most recreation activities act to optimize and equalize a person's stress level. A certain amount of stress can actually increase productivity and creativity. In sum, ERSF programs have a lot to do with reduced absenteeism and turnover, increased job satisfaction, increased performance, improved general health, and reduced cost of care. Quite simply, in this day and age of complex technology and change, employee recreation programs can really increase profits.

HIGH-TECH RECREATION EQUIPMENT

The profile of athletics, in an era when technology can ostensibly fix anything, seems to go through one transition after the next. Today's athletes seem to come more well-equipped than the chariot riders in ancient Greece.

More interesting, however, is the extent to which contemporary athletes, professionals and amateurs alike, are dependent upon a whole array of paraphernalia. We have almost reached a point when it is not enough to say that you lack the necessary coordination to be a good skier or halfway decent tennis player. The chances are strong your ski instructor or tennis pro will recommend that you go out and purchase a new "whatever" to improve your performance.

Sports equipment has always been a crucial link between the athlete and the game. Now, more than ever, a host of technical refinements are introducing a whole new line of "improved" basketballs, tennis rackets, aerobic shoes, golf balls, baseball gloves, bicycle gears, and safety helmets. The improvements in sports equipment are being made so fast that in some cases, as with the present generation of tennis rackets, they are actually revolutionizing the sport itself. On the teaching side of the games, technology is changing the "look of the lesson." Two excellent examples are found in Florida.

The Jack Nicklaus Academy of Golf in Orlando and the Nick Bollettieri Tennis Academy in Bradenton both use computers, high speed video cameras, and heart monitors to diagnose the problems and improve the performance of duffers, hackers, and tournament players alike. Instructors at the former institution aim to develop the perfect golf swing for every registrant. Within a three day program, the students receive daily 45-minute lessons in front of video cameras. While the tapes are played back, a computer-generated stick figure is superimposed over the image of the learner to illuminate deviations from the ideal movements. See Figure 13.9. At the tennis school, the heart monitor is one of the chief teaching aids designed to train players to perform competitively on a consistent basis. These professionals believe players function at their best skill level within a narrow range of heart rate.

The manufacture of leisure equipment is a major industry. One of the most common sales promotion gimmicks used by sporting goods firms is to sign well-known athletes on to use certain products exclusively. Sporting goods companies are subsequently under tremendous pressure to constantly improve product lines so their sponsored athletes maintain an edge over the competition. Also adding fuel to the fire are governments and national athletic organizations, coaches, and athletes who are usually clamoring for better equipment. Consumer tastes and a slight increase in the amount of discretionary income people have to spend on their leisure have also altered the shape of some traditional products.

Manufacturers use the latest in space-age materials and computer-aided techniques to improve the life, power, and controllability of tennis rackets. Shoe designers boast their particular aerobic model represents the latest technology in attire for the feet! The adult segment of the bicycle market has grown considerably in the last decade. This has motivated manufacturers to develop an "elite" line of bicycles aimed at the quality conscious adult buyer. For the back-packing devotee, the formulation of advanced fibers and fabrics is starting to eliminate some of the discomforts caused by inadequate clothing

Figure 13.9 Dr. Ralph Mann, former Olympic medalist and now President of CompuSport, uses a computer generated model golf swing he researched from the performance of over 50 top PGA golfers on the professional tour. Dr. Mann tailors the model to a student's body dimensions, and overlays the model on the student's actual golf swing. (The Jack Nicklaus Academy of Golf, CompuSport at Grand Cypress & Grand Cypress Resort)

design and construction. DuPont introduced a new fiber called Thermax which combines the softness of cotton with a wicking ability that pulls moisture away from the body for evaporation. The wearer stays drier and is much more comfortable. The list of examples to portray the use of technological genius to build new toys or improve the ones we already possess goes on much further. Regardless of your favorite sport or recreational hobby, in one way or another, technology will surely modify its profile in the near future.

SUMMARY

Social institutions exist in all cultures around the world. Some are highly respected due to their longevity and coincidental ability to preserve tradition and nurture local customs. Others are recognized as modern social groups that serve as a type of substitute for more conventional institutions. In either case, people tend to compartmentalize their life-long objectives and aspirations into specific activity areas. A few of these compartments were discussed in this chapter including family, religion, education and recreation.

Technological developments have certainly affected the general profile of these social institutions. Each one continues to be operative in our society at varying degrees of stability. One group of sociologists reports that: the family unit is existing only on shaky ground, technology is replacing religion, real live teachers are becoming obsolete, and serious adults believe that buying more toys may be the answer to their loneliness. On the other side of the fence, a more optimistic group of social scientists contends that: marriage and family life are both back in style, the strength of religious affiliations is on the incline, technology in the classroom can assuredly enhance curricular goals, and a lot of adults believe that recreational activities should be productive rather than a passive financial investment. Regardless of which group you can most readily agree with, social institutions are still the structural mainstay of our civilization.

DISCUSSION QUESTIONS

1. Identify and describe several characteristics of a nuclear family, an extended family, and a surrogate family. Explain how they are similar to each other in contemporary society.
2. What are some of the personal expectations you might list for your prospective spouse to peruse at the onset of your marital agreement? How are these expected outcomes different than the ones your parents may have had when they got married?
3. Which, if any, contemporary medical procedures do you believe to be acceptable for use by couples who find that they are unable to conceive a child?
4. Explain how the responsibilities of teachers in our society are being modified as a result of the rampant pace of technological change.
5. Identify several ways the "toys" manufactured for the adult population in this country seem to perpetuate their visions of childhood. Give specific examples. What sorts of "toys" are marketed for children to enhance the process of socialization?

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Chapter 14

THE TECHNOLOGIST'S RESPONSIBILITY FOR THE FUTURE OF TECHNOLOGY

DATELINE

Atlanta, Georgia

The World Health Organization, during the 1940s, established an international network to stand alert to flu outbreaks. Health officials from roughly 90 countries routinely collect fluid samples from infected people and isolate viruses. Prevalent varieties are either sent to the Center for Disease Control (CDC) or to a similar lab in London. These national laboratories employ scientists who attempt to predict which strains are poised for a big strike in order to recommend the correct ingredients for the next season's vaccine.

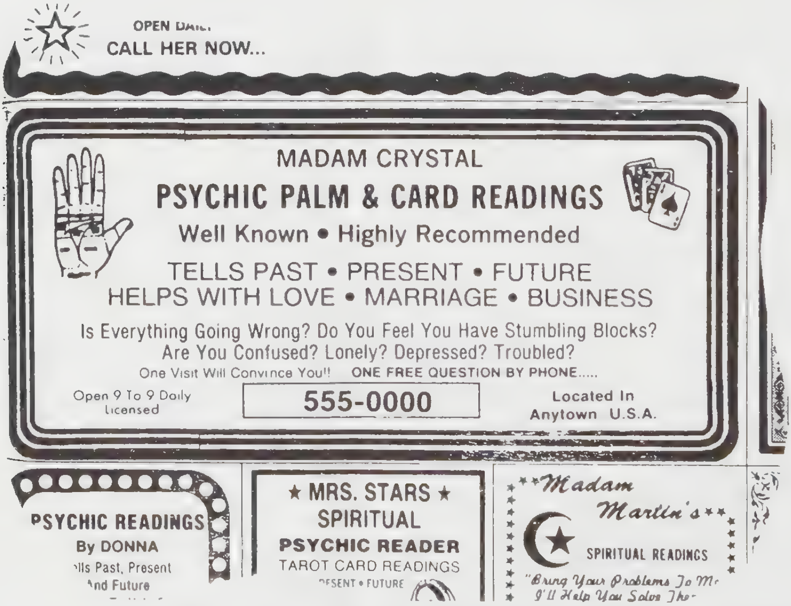
For most of the year, these immunization experts work like sleuths stalking a shifty opponent. By the time spring arrives, they should be more or less in agreement on their forecast. Full scale vaccine production must get underway by early April if they expect the serum to be available by the end of autumn and the start of the "flu season." Their predictions involve a certain measure guesswork since the process of isolating a flu virus is very much like hitting a moving target.

Even still, these labs form the world's cornerstone of the surveillance effort. The influenza virus is a formidable foe. There are two major types known as A and B, and numerous subtypes or strains. Flu viruses travel quickly and they change radically in a span of a few short weeks or months. The present surveillance system is adequate to guard the world against a disaster like the 1918-19 epidemic that killed 20 million persons, but it is far from perfect. Virus-filled vials sometimes get lost in the mail. Communication between American and British flu experts occasionally breaks down amidst competition to secure viruses and to make a winning prediction . . . .

INTRODUCTION

Speculation about the future has been a favorite social pastime throughout all of human history. Greek and Roman myths are full of tales of supernatural beings who could foretell the future. The early biblical prophets were believed to possess divine inspiration and the "God-given" ability to predict or "prophecy" the future. Tribal cultures around the world have been ever trusting of their local "witch doctors" when there was a need to forecast future events. Most everybody, at one time or another, has taken a stab at making a prediction concerning his or her own destiny. Think about this for a moment. Have you ever had your fortune told at a local carnival or county fair? Have you ever noticed roadside advertisements for palm readers in small tourist towns? Have you ever scanned the "Yellow Pages" for a listing that might put you in touch with a spiritual consultant? See Figure 14.1. Have you ever read your daily or annual horoscope? Each of these simple examples presents a case of curiosity about one's life at some point in the future.

Until recently, forecasting activities were mostly left to prophets and philosophers who were thought to enjoy special powers of insight. Today, when business organizations and government agencies need an image of tomorrow or a projection about next year, they submit their request to a whole new breed of intellectuals. Although any number of titles have been used to describe these



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PSYCHIC READINGS
By DONNA
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nd Future

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PSYCHIC READER
TAROT CARD READINGS
ESENT • FUTURE

***Madam*
*Martin's***
SPIRITUAL READINGS
"Bring Your Problems To M
I'll Help You Solve The

Figure 14.1 The "Yellow Pages" may use the subheading "Spiritual Consultants" to advertise for a wide assortment of businesses professing to predict or forecast future events in your life.

individuals, they are highly respected as professional futurologists. Unlike the old-fashioned soothsayers, these consultants are respected for their intuitive ability to analyze recent events and study the laws that govern social, political, and economic trends in order to provide future forecasts.

A little more than four decades ago, futures studies and futures research did not really have an organized existence. The birth of professional futurology coincided with the realization that history itself did not follow any ironclad laws and, therefore, the future must belong to mankind. It also seemed to occur at about the same time our destructive capacity created a new source of anxiety about the future—nuclear weapons and the later evolution of the Cold War. One of this nation's first major "think tanks," the Rand Corporation in Santa Monica, CA, was established by the Air Force and Douglas Aircraft in 1946. Its initial mission was to do a more creative job of dreaming up military technology than the Soviets.

Since that time, hundreds of private research institutions and laboratories have been launched into operation. Think tanks have essentially become an American phenomenon. It is unlikely any other country awards such a great amount of significance to private institutions that are, in many cases, in business to stimulate creative thinking and influence public decision making. These futures oriented firms are responsive to the needs of industrial corporations as well as government agencies and regularly pull in multi-million dollar contracts.

Regardless of the future time frame (6 months, 2 years, 5 years, or 20 years down the road), the land of the future has become the home of futurology. A large and still growing group of future inspectors has been keeping its watchful eyes on the nation and the world over the past couple decades. They routinely observe and report on the significant trends they have detected in society, industry, technology, and international relations. In the process, they have created a variety of observational forecasting techniques including: futures wheels, content analysis, trend impact analysis, and Delphi studies. Their ongoing investigations have transformed the study of the future into a profession with its own specialist institutions and several widely circulated journals.

More has been written, discussed, debated, and revealed about coming events in the last quarter-century than has been even mentioned in the entire brief history of futures thinking. The future has been a central topic of a great many books and articles, television programs, feature films, journals, societies, congressional committees, institutes, and government commissions. By the end of the 1960s, the various permutations had caught the interest of a wide range of readers while a network of communicators spread the latest "predictions" about tomorrow's world. One major source of information in the United States was the World Future Society and their journal entitled *The Futurist*. Chartered in 1966, this community of future-minded citizens came from a diversified lot of professions. Headquartered in Washington, D.C., membership in this still active organization some twenty-odd years later exceeds 30,000.

Shortly after the publication of Alvin Toffler's notorious *Future Shock*, the United States Congress passed the Technology Assessment Act of 1972. This legislative decision established the Office of Technology Assessment (OTA) as a congressional support agency. Its members are supposed to provide congressional committees with objective analyses of the emerging and often highly technical issues of the late 20th century. Since OTA's activities are based on the need for the social consequences of technological applications to be anticipated before public policies are enacted, technology assessment has become a branch of futurology. It, together with several other forecasting strategies, is discussed in this chapter with reference to future prospects for various technologies.

Studies and investigations are constantly being set up to project or predict the future state of a particular technology so its impact on society can be assessed. Data accumulated by these researchers is also being used to determine ways in which the United States can regain its edge in technology development. Futures studies are invaluable to contemporary corporations who require a reliable estimate of where their industry will fit in a changing global economy. Strategic technology management seems to be an essential feature in the personality profiles of scientists and technologists who aspire to assume responsibility for the future of humanity.

1. As other nations continue to build up their scientific and technical skills, will American dominance in science and technology cease to be a reality?
2. How can the disciplines of technology assessment and risk assessment be most effectively utilized by government agencies and private citizens alike?
3. Should those who manage technology inside the plant also be responsible to oversee its successful implementation in the external social environment?
4. What types of forecasting techniques should "responsible" scientists and technologists rely on for critical moves and decisive actions regarding specific, and possibly controversial technologies?

KEY CONCEPTS

As you complete your reading of this final textbook chapter, you should already be familiar with most of the concepts being presented here. You will come across a few terms and phrases included on this list. If they are new to you, make an effort to understand their meanings.

Technology Assessment
Futures Wheel
Risk Assessment
Optoelectronics
Content Analysis
Delphi Study
Content Analysis
"Telesis"
Epidemiology
Trend Impact Analysis

TECHNOLOGY RESEARCH: ON THE LEADING EDGE

Few economists would be willing to deny that technical innovativeness and scientific curiosity have stimulated a large portion of the growth in the United

States GNP during the past couple of decades. These are the main ingredients in the formula responsible for the amazing surge in the United States standard of living since the end of the second World War. Technological innovation, combined with capital and an abundant supply of natural resources, has made a significant contribution to this nation's overall level of productivity throughout the last half of the 20th century. The power of American ingenuity is legendary, but the rest of the world seems to be ready and determined to catch up. American dominance in science and technology on a global scale may actually be faltering. A significant weakening of its lead position could threaten the future prosperity and well-being of its citizens.

Technological change is exciting but it worries a lot of companies who fear they will not be alert to react quickly enough to stay in the race. These days, they seem to be scrambling even more diligently in anticipation of the accelerating twists and turns of novel technologies. Companies like National Cash Register (NCR) and Minnesota Mining and Manufacturing (3M) are streamlining their internal research projects. Smaller companies, wary of the huge financial commitment which technology development requires, are joining research consortiums or hiring outside consultants to keep them on track. Firms not even involved with the manufacture of high tech products have started to set up internal technology units to keep abreast of computer refinements and software enhancements that might affect their own industrial vitality.

Technology advances and changes so quickly that companies find themselves aiming at a series of elusive moving targets. They no longer have the luxury of planning years in advance and assuming the rules of the technology contest will remain unaltered. As product life cycles become shorter and shorter, businesses will continue to become obsolete. A few corporations have indicated their belief in decentralization as a key to long-range technology planning. For example since the early 1980s, 3M Company has established separate product divisions. One division handles short term research. Another layer of laboratories oversees research which might produce benefits 5 to 10 years hence. A third research team watches for developments even further in the future. Flexible planning for technology change is crucial to staying ahead in the global high tech race.

Whatever form of crystal ball a company, or even a nation, uses to plan for the future, it can not anticipate each and every technological twist of fate. Aggressive technology development programs can be quite risky. Corporate executives are often fearful of making hasty decisions leading to heavy financial losses. On the other hand, the price of advice to help guide their long-term speculation is no cheap investment either! At the present time, Gartner Group Inc., a computer consulting firm located in Stamford, Connecticut, charges $15,000 a year for a subscription to its bi-weekly news letters on noteworthy advances in the industry. The Microelectronics and Computer Technology Corporation (MCC) charges companies an entry fee of $250,000 plus a percentage of its $75 million annual budget. You may recall that MCC is a high tech research and development consortium, headquartered in Austin, Texas, started up in the early 1980s by competing United States firms who received the (somewhat reluctant) blessing of federal antitrust officials. Artificial intelligence and the technologies associated with supercomputers are currently their main areas of research and development.

Technological prowess is a direct result of a long chain of efforts ending with new and useful products able to compete successfully on international markets. During the final years of the 20th century, the United States will either remain close to the leading edge of technology development or fall behind its competitors to become a technologically stagnant nation. Its residents will either continue to be the beneficiaries of economic prosperity, or become the victims of dependency on foreign nations for advanced products and services. In order to prevent the latter situation, tomorrow's technologists and industrial leaders should already be thinking about and learning how to sharpen the country's competitive edge.

RE-STRUCTURING OUR RESEARCH EFFORTS

The quality and diversity of United States research in science and technology is quite impressive. The major contributors to the United States research and development system include industrial firms, the federal government, colleges and universities, and other non-profit institutions. Nearly three-fourths of the research and development projects in science and technology are presently being performed by the industrial sector. The remaining 25 percent is divided among the other three categories of performers with the federal government accounting for the next largest share.

Recent trends in national support for technological and scientific research are commonly analyzed by the character or the specific descriptions of the funded activity, Figure 14.2. Research projects are often described as being either basic or applied. BASIC RESEARCH is fundamental and often stems from a desire to fill gaps in the existing knowledge base rather than a desire for a practical application. APPLIED RESEARCH is directed toward gaining knowledge or understanding specifically related to an anticipated end use.

UNITED STATES RESEARCH AND DEVELOPMENT EXPENDITURES,
BY CHARACTER OF WORK, AS A PERCENT OF TOTAL
R & D EXPENDITURES

	1960	1976	1980	1985
	(Percent)			
Total	100.0	100.0	100.0	100.0
Basic research	8.9	12.8	12.9	12.5
Applied research	22.3	23.2	22.4	21.5
Development	68.8	64.1	64.6	66.0

Figure 14.2 Table which reflects national R&D expenditures by character of work as a percent of total R&D expenditures. (Science Indicators)

Applied research in industry is generally aimed at the discovery of new scientific knowledge used toward achieving the corporation's commercial objectives. The line of distinction between these two types of research is quite permeable. Academic scientists whose promotions are often contingent upon new discoveries tend to describe their research endeavors as "basic." Identical projects may be labeled "applied" by a government agency or industrial firm in order to justify their credibility to a funding source.

DEVELOPMENT, the next step beyond applied research, is where the results of research are molded to fit a particular application. Development projects are usually directed toward the full-scale production of useful materials, devices, systems, or methods. The initial design and development of prototypes and processing techniques also fit beneath this heading.

National investment in research and development has been increasing in constant dollars since the mid-1970s. Federal R&D budgets have fared relatively well since the early 1980s. However, the defense component has been the largest beneficiary of recent increases in federal R&D spending. As a result, civilian R&D expenditures in the United States currently constitute a smaller share of the gross national product than in either West Germany or Japan. Furthermore, while total federal spending for basic research has increased almost 50 percent since the early 1970s, federal support for basic research at universities has grown only slightly more than the inflation rate.

We seem to have reached a point where it is once again essential to re-examine the nation's technology research priorities. It is apparent that defense, energy and health applications will continue to occupy a prominent position among federal research investments. These emphasis areas should be balanced out with other, well-organized civilian basic research projects such as genetics, fiber optics, magnetic transport, etc. In that the traditional boundaries between scientific disciplines have become less distinct, attention and energy must be focused on multi-disciplinary pursuits for knowledge and understanding. The complexion of research methodology is changing as well. Disciplines which have long been dominated by solo investigators in self-contained laboratories are starting to require larger, more elaborate and more expensive instruments. The cost factor alone makes it necessary for these pieces of equipment to be shared by several researchers working in teams on a variety of projects.

Research efforts around the world are producing new knowledge and information at an accelerating pace. The time lag between basic research and applied technology is becoming much shorter. Subsequently, cooperation between universities and industries is expanding to perform work in areas like biotechnology, microelectronics, computer hardware/software, and materials science. Cooperative arrangements like these are highly beneficial to both parties but they are not often executed without a certain amount of strain. Essentially, private industry's concern over proprietary rights, or government's concern over the confidentiality of its projects must be balanced against the importance of unobstructed communication to the academic sector.

We must continue to nurture working relationships among universities, industries, and governments to enhance the flow of personnel and research findings. This assertion has prompted the National Science Foundation (NSF) to implement several creative programs which permeate traditional institutional and disciplinary boundaries. A number of U.S. universities have already been able to establish engineering and technology research centers as a result of federal funding through the NSF and monies from groups of company sponsors.

These university centers provide a unique research environment where academic and corporate researchers can pursue questions of common interest in areas like genetics, systems engineering, computational science, and materials testing. At Purdue University for example, Alcoa, Cincinnati Milacron, Control Data, Cummins Engine, Ransburg, and TRW are investigating the potential of intelligent manufacturing systems. The University of California at Santa Barbara has designed and set in motion a center for robotic systems with the assistance of 25 corporate partners including Bell Laboratories and GMF Robotics.

Despite recent efforts in the right direction, there is still too large a gap between the universities and industry in this nation's research and development arena. The parties are learning how to work together, but neither has yet been able to completely master the exercise. Universities need industry because the nation's economic future depends on industry. Academic scientists and technologists need to be informed about industrial problems in order to more succinctly design their own research projects and assignments for their students.

On the flip side, industry needs both the graduates the universities produce and access to the talent and creative ideas that flourish in their free and open climate. It is certainly not enough for corporations to recruit universities' graduates each year and tempt away their professors with larger salaries. Industrial leaders must assume an active and ongoing advisory role in shaping both educational curricula and applied research programs.

Unlike the compelling research and development objectives driven by World War II, the Cold War, and the Apollo program, there are no singular unifying issues to keep things on a smooth course well into the end of this century. Contemporary social problems seem to be much more diffuse, but not any less pressing, than those just mentioned. This feature makes it more difficult to reach a national consensus with regard to our future research priorities. Future success in science, technology, and engineering will be sustained to the extent this country's research community can survive some long overdue restructuring. Along the way, let's hope their responsiveness to public concerns will be fortified and the integrity and excellence of standards in their research will be heightened.

LEADING EDGE TECHNOLOGIES

Attempting to predict which technologies will be frontrunners in the years ahead vs. those that will simply plod along in the middle of the pack is not an easy task. In fact, if you were to travel around to interview scientists at work in a variety of research labs across the country, each of them would easily contend that their efforts are on the "leading edge." Who should say the persons working on isolating a cure for various forms of cancer are more important than those trying to devise a stream of new "space age" materials? No one should of course! Labeling one technology as being any more useful or significant than any other is second guessing reality. Such second guessing may lead to the curtailment of life-saving breakthroughs. In any case, there are those scientific experts among us who insist on identifying a series of "critical" or "leading edge" sciences and technologies paving the way toward a miraculous future in the next century.

Advances being made in the fields of medicine, high technology, and genetic engineering are totally re-charting the course of human history and transforming the way human beings live on this planet. As you have read, some of the consequences associated with these technological changes are not always pleasant. Regardless, scientific breakthroughs will continue to take place in the abstract world of theory as well as in the concrete achievements of sophisticated machines. Some of these devices include:

☐ Neural net computers which can imitate the internal mechanics of the human brain.
☐ Table top instruments which will speed up the mapping of the spiral step-ladder DNA molecule that holds the key to heredity.
☐ Exotic and highly sophisticated microscopes which enable scientists to see actual atoms.
☐ Supercomputers which can simulate everything from the impact of a laser beam to a full scale thermonuclear world war.

As scientists throughout the world continue to decipher the remaining mysteries of the atom and the gene, it is likely the most far-reaching advances, over the next two decades, will occur in the fields of physics and molecular biology. Ongoing research in other fields like microengineering, artificial intelligence, materials science, and optoelectronics will also make lasting contributions to the well-being of humanity.

Life Sciences

The commercial strength of biotechnology is concentrated in genetic engineering, sometimes called recombinant DNA technology. Another promising breakthrough is taking place in the development of monoclonal antibodies. These proteins can unerringly seek out foreign cells which they lock on to as diagnostic markers or as carriers of drugs designed to kill the invaders. Safer vaccines are also being developed which mimic only a small part of the structure of a virus and are thus less likely to inadvertently trigger a disease in the recipient's body. Several genetic research firms are investigating the possibility of producing an AIDS vaccine. Some success has been realized in the labs' research animals, but they have yet to establish the vaccine that will be effective in people.

Biotechnology also spells big changes in agriculture. Tomorrow's crops will be engineered to resist freezing temperatures, drought, and a vast array of disease-carrying pests. Newly engineered genetic substances will one day soon be in common use to neutralize sewage, make low-cost fuel alcohol from vegetation, and extract more oil from seemingly exhausted wells. The range and depth of United States activity in biotechnological applications is presently unmatched anywhere in the world. The Japanese, however, are racing to strengthen their capabilities in the life sciences because they believe that biotechnology will be a sure-fire catapult to spring them into the 21st century as a world leader in technology. If the United States slows down in its basic research in this field, other nations will soon take up the slack. It appears Japan, in particular, has the requisite patience and determination to do so.

Materials Science

Contemporary scientists have the capacity to tailor the basic structures and properties of materials to suit their specific needs. Exotic new materials and some old familiar ones will soon replace such old stand-bys as steel, glass, lead, zinc, and copper in a series of important applications. A stream of new materials is already finding its way out of the labs: glass that bends without breaking; metals that stretch; plastics that are stronger than steel and can also conduct an electric current.

New materials technology is converting one of the oldest fabricated creations known to man, ceramics, into materials with a vast display of applications. High tech ceramics are derived from very fine clays, purified, and then augmented with other substances to produce ultra-hard pressings and moldings. The Japanese have already unveiled experimental versions of all-ceramic automobile engines. This technology also has great potential for introducing unprecedented efficiency and performance into aircraft and truck engines. Advanced ceramic applications will eventually turn up in instrumentation. They show a great deal of promise for use as sensors for extremely high-temperature, radiation, or corrosive environments; industrial parts where heat and wear resistance are crucial; and maybe even in medical bone replacement uses.

New polymers will make a big splash in the packaging industry. Before the century is out, they will probably have replaced metal, glass, and paper in just about all food and beverage packaging. Food companies have already begun to market various lines of products sold in containers which can be heated in a microwave oven and then used as tableware, Figure 14.3. Mixed-media polymers (plastics reinforced with other synthetic fibers and/or carbon filaments) can be designed to fill all types of specifications: special aerobic shoe materials; heat resistant plastics that look like cast iron and can be used in the manufacture of hot plates; especially slippery varieties of plastics better than anything now known for use as bearings and bushings; flexible plastic armor for law enforcement and military use; and base materials for high density laser optic storage disks. Stay tuned for more in this exciting field of technology!

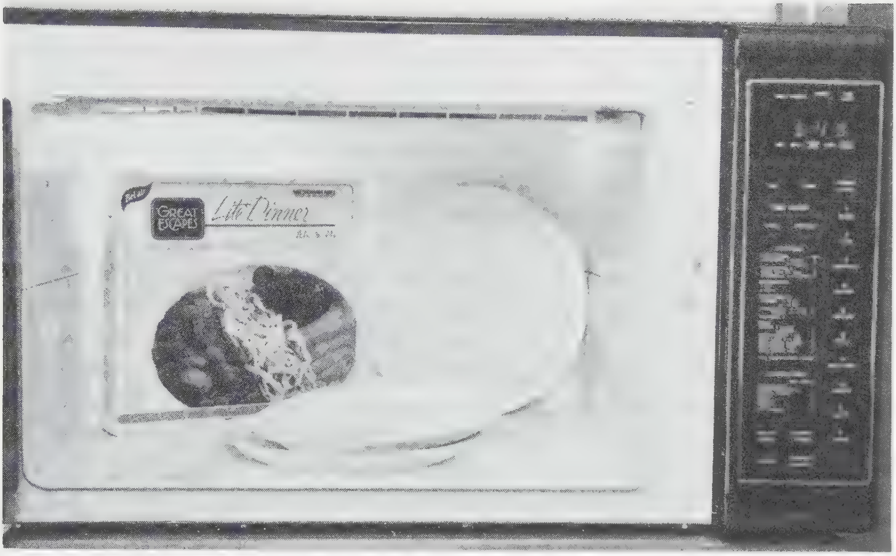

Figure 14.3 This frozen, low calorie dinner is one example of a long list of prepared food products packaged in a microwave-safe container for dual use on the dining room table. These may not be as impressive as your grandmother's fine china, but they are quite functional nonetheless. (Michael Dafferner)

Optoelectronics

This technology represents a marriage between electronics and optics. It is already producing important commercial products such as optical fiber communication systems. The Japanese presently lead the world in optoelectronics which is widely expected to be the backbone of much of the next generation of information-based technology. This projection is based on optoelectronics uniting the electron with the photon to attain greater efficiency in data processing and transmission than electronics can achieve by itself. Photons are discrete units of electromagnetic energy which have zero mass and no electric change. They can be employed as more compact carriers than electrons. Photons can also transmit massive amounts of data as laser pulses through hair-thin glass fibers. Optical communication networks have already started to replace less efficient copper wires within and between cities around the globe.

Next on the horizon may be the development of "chips" combining electronic data processing with photonic switching and transmission. Integral to a system with this type of chip are microscopic semiconductor lasers made from a special type of gallium arsenide. Chips permitting photons to be switched may eventually lead to ultra-fast computers working entirely through optics (computer scientists are still somewhat skeptical about this concept). Optoelectronics also includes such devices as light emitting diodes and various types of larger lasers. Breakthroughs in the latter discipline will most likely have a great deal of significance for military applications.

In the field of information storage, optoelectronics technology will introduce an erasable optical storage disk. These could ultimately replace memory chips, magnetic tape, floppy disks, and the hard disks present day computers use. These new disks apparently have an unequaled capacity for data, which can be recorded, read, and erased as needed by microminiaturized lasers. The large storage capacity feature will certainly be a boon to the field of artificial intelligence where programs eat up a lot of space. In the home entertainment market, it is likely optical disks will displace at least a few of the recently released compact discs. While CDs can not be erased, optical disks can be erased, which means consumers will be able to record music from other sources as often as they wish.

In optoelectronics, only Bell Labs is presently mounting research efforts remotely similar to what a single Japanese company like Hitachi is doing. Overall, the United States may actually have more researchers in optoelectronics than Japan does, but they are scattered off in small groups. Most are involved with defense-related work and only secondary remnants are available for civilian industry. None of the teams is currently as production oriented as their Japanese counterparts. It is likely this situation will change as we restructure our research and development network and prepare to enter the 21st century.

LIFE ON THE EDGE

The above three disciplines of life sciences, material science, and optoelectronics were highlighted to illustrate the competitive nature of scientific research and technological advancement. Although being at the "cutting edge" of a discovery sounds rather exciting, scientists' lives are often full of stress and anxiety and sometimes even guilt over their projects. They may actually describe "life at the edge" as long periods of demanding, exhausting, and commonly frustrating labor, interspersed with occasional moments of euphoria.

Once an individual earns elementary status as a scientist by completing the Ph.D. with a creative dissertation, he or she is likely to enter some type of research laboratory or academic institution. The world of research is characterized by a constant search for funding where scientists submit any number of proposals each year. The funding opportunities may come from agencies who have specific guidelines and expectations. Rarely does a research grant come with "no strings attached!" Research specialists must then make choices as to whether to pursue unknown areas out of curiosity (basic research) or to construct their research designs toward the money sources. These types of choices are especially objectionable, when researchers, who are personally committed to research for human progress, discover funding for their specialty is available primarily from the Department of Defense. Unfortunately, in order to be a successful scientist these days, one must possess a certain amount of entrepreneurial drive.

Other sources of anxiety at the front line come from the realization that your "colleagues" might get there first. The inexorable (relentless) pace of the entire research enterprise makes it almost impossible to even keep up with the new literature. Since there are no prizes for second place, scientists often live with the pressure to succeed quickly—in order to gain the rewards of precedence. Some people feel this frenetic race to win first prize often diminishes the quality of the research being conducted.

Life at the edge is replete (filled) with criticism and peer evaluations. New discoveries must stand up to professional confirmation first and public scrutiny later. There is always the chance your new found theory is either incorrect, incomplete or invalid. For whatever excuse, society seems to take a certain amount of pleasure in witnessing scientists "scrape the egg off their faces." Perhaps this is one justification for the existence of a "scientific community" wherein scientists and technologists can occasionally lose touch with scientists in other disciplines and get away from the general public.

Scientists determined to "stay with it" until they witness a breakthrough may find life on the edge to be quite stimulating. For others, the work schedule may lead to insomnia and deep periods of depression. The struggles of the solitary scientist go largely unnoticed by the rest of the world. Even though a large portion of the science and technology projects are being monitored by research teams, the individual scientist still plays a central role in the process of inquiry leading to benchmark findings. Although there is no magic formula for creating or becoming an outstanding scientist, one thing seems clear. To survive on the edge, these individuals must be competitive, curious, and brilliant. Furthermore, they must take extreme satisfaction in being able to solve one of nature's riddles before anyone else does via high caliber research, whatever the discipline.

TECHNOLOGY MANAGEMENT

Embarrassment is an experience most of us prefer to avoid, yes? Many persons fear they will be humiliated if they do not know the answer to a question, or, worse yet, give an incorrect response to a question. Well, when it comes to our contemporary world of science and technology, even the most highly trained, well-educated "experts" among us must accept the fact that what they don't know is many, many more times greater than what they do know. Ironically, a high state of ignorance seems to be a universal condition in today's society. While this state of affairs may sound rather bleak on the surface, the balance of knowledge and understanding seems to average out favorably among the individual technical disciplines in our midst. To a great extent also, interdisciplinary breakthroughs have led to lower levels of ignorance among the "experts" who are often called upon to work outside their immediate area of specialization.

Somewhat related to the dialogue surrounding technological ignorance vs. scientific specialization is a discipline known loosely as technology management. For many years, American business students have been taught a good manager can manage anything and that it is not necessary to have a technological understanding of the process one is attempting to manage. In some settings, we seem to have reached a point where American managers have lost contact with the technologies they are supposed to be directing and monitoring for productivity. By comparison with the rest of the world, a higher percentage of American managers come up through non-production jobs in business, law, accounting, and marketing. The number who have an applied technological background is much lower than found among management personnel in both Europe and Japan.

Non-technically-oriented managers may very well *understand* the technologies being used and developed by their own firms. But, they generally lack the *intuitive* capacity to determine which of the possible technologies out on the horizon should be further developed and which should be ignored or discarded. Pacific Bell, a west coast telephone company, uses the term "telesis" to describe this skill. For them, TELESIS means "progress intelligently planned." This level of intuition and type of insight only comes from first-hand experience. Engineers, technologists, and scientists are often reprimanded for believing too strongly in untried technologies and hastily plunging ahead where caution is warranted. Sometimes this charge is true, but it seems that managers who possess a technological background might end up with a more successful betting record than those who lack an understanding of technology.

Does the field of technology management say every MBA graduate should also possess an undergraduate degree in science, technology, and/or engineering? Not exactly. It does suggest effective managers should be able to:

☐ Understand scientific arguments.
☐ Interpret computer-generated documents.
☐ Synthesize statistical information.
☐ Understand the dynamics of technical change in the global economy.

The art and science of technology management encompasses a long list of responsibilities including: Risk Assessment, Environmental Scanning, Measurement and Control, Competitive Analysis, Strategy Formulation, Technological Forecasting, Organizational Climate, Corporate Structure and Culture, and so forth. Corporate managers who are well versed in technological issues represent a profile characteristic and the necessary human element long overdue in this country's business environment.

TECHNOLOGY ASSESSMENT

Managerial short-sightedness with reference to technological decision making is generally a result of working within a very narrow perspective of one's own business or industry. One form of the problem surfaces when industrial leaders fail to broaden their vision to analyze how technological progress in their own or related industries will affect their future status. Another type of crisis situation might occur when a company or industry actually has advanced technology available to them but does not recognize how to apply it in a strategic manner. The first example illustrates the failure or even reluctance to stay informed about emerging technology. The latter amounts to failing to utilize technology in a timely manner with regard to market expectations and economic conditions. In either case, the managers in question are somewhat myopic (short sighted) in their approach to technology assessment.

The U.S. Office of Technology Assessment (OTA) defines this concept as it relates to a projection of the possible future state of a technology and an assessment of its potential impact on society. The bulk of OTA's work is focused on comprehensive assessments taking one to two years to complete. They deal with all sorts of technology issues earmarked by congressional members as areas of concern or controversy. The OTA staff consists of skilled professionals who possess advanced training in physical science, life science, engineering, and social science. Throughout each project, OTA makes use of advisory panels of experts on the particular topic being investigated. These panels typically include distinguished scientists and engineers, labor union members, industrial representatives, academicians, public interest group members, state and local government officials, and the citizenry at large. Essentially, these panels often help to formulate OTA studies by defining them initially, critiquing them while in progress, and reviewing the reports before they are released. OTA assessments are subsequently published by the Government Printing Office and are frequently reprinted by commercial publishers. Figure 14.4 provides a partial list of the types of reports this office has published over the past several years.[1]

Technology assessment reports may be respected as documents which guide public policy making decisions. In an industrial setting however, technology assessment is an important component of managing current as well as emergent technology developments. Strategic decisions to establish a national telemarketing center, switch over to a more efficient bottling line, or totally change the container specifications for your company's product should not be made without a comprehensive assessment of the potential consequences of these actions. For instance, failure to recognize the price of glass bottles may soon become prohibitive compared to plastic containers would make the investment in a brand new glass bottling line somewhat faulty and very costly for the firm. The word "strategic" implies foresight, logic, statistical analysis, and an awareness of trends in the making. When it is used as a modifier for the activity known as decision making, technology assessment becomes part of the equation.

Technological forces have begun to play a much greater role in corporate strategic planning. Within a company's annual strategic formula, emerging technologies can present seemingly endless opportunities for a whole range of new products. On the down side, new technology is also a gamble that eats up precious research time and money without any real assurance of success. Fierce global competition in many industries has led to a new zeal to optimize the return on investment in new or modified technology.

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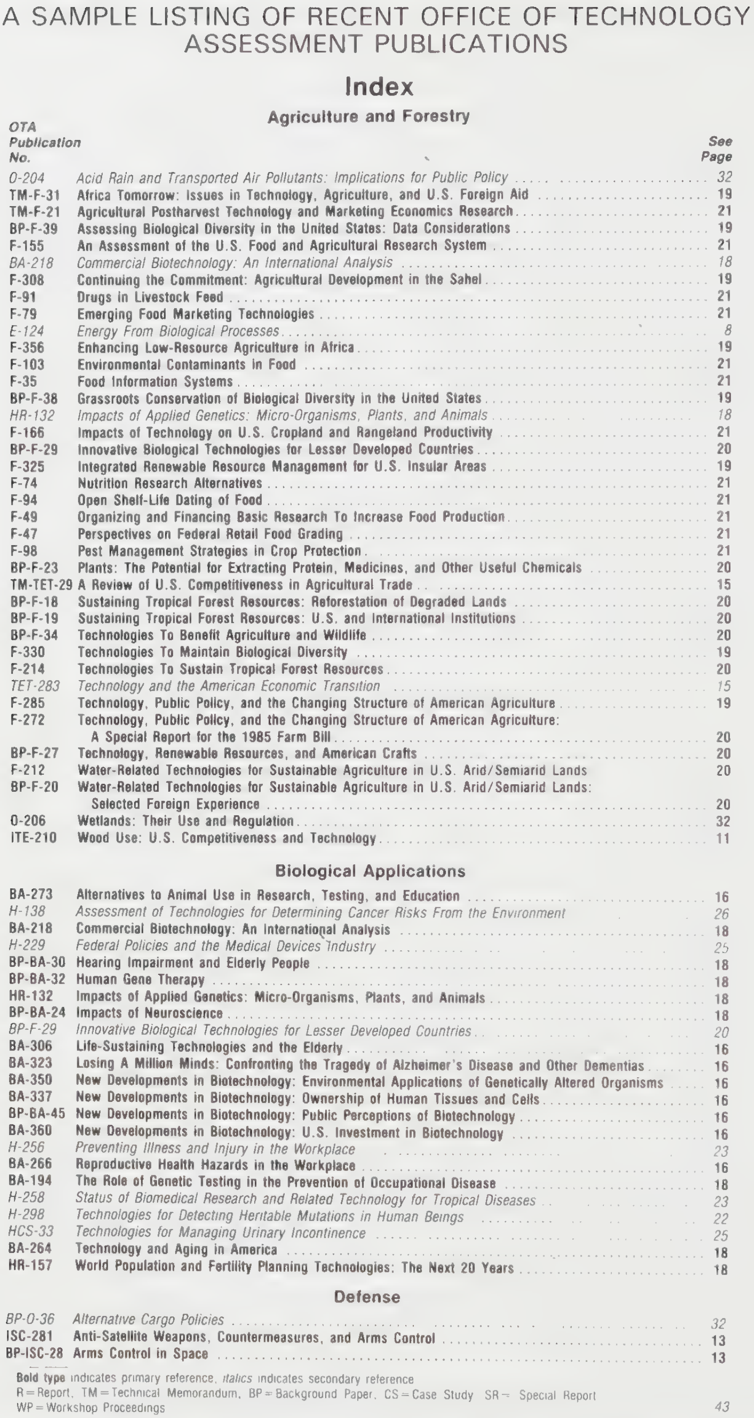
[1] For information on the operation of OTA or the nature and status of ongoing assessments, you can write or call: Congressional and Public Affairs Office, Office of Technology Assessment, U.S. Congress, Washington, D.C. 20510. Telephone: (202) 224-9241.



A SAMPLE LISTING OF RECENT OFFICE OF TECHNOLOGY ASSESSMENT PUBLICATIONS

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Bold type indicates primary reference, *italics* indicates secondary reference
R = Report, TM = Technical Memorandum, BP = Background Paper, CS = Case Study SR = Special Report
WP = Workshop Proceedings

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Figure 14.4 List of typical Office of Technology Assessment Publications.

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E-237	**Environmental Protection in the Federal Coal Leasing Program**	**8**
E-110	**The Future of Liquefied Natural Gas Imports**	**8**

Bold type indicates primary reference, *italics* indicates secondary reference
R = Report, TM = Technical Memorandum, BP = Background Paper CS = Case Study, SR = Special Report
WP = Workshop Proceedings

Source: Office of Technology Assessment, List of Publications April, 1986

Figure 14.4 Continued.

In an effort to reduce the percentage of "bad" risk bets, an increasing number of corporate executive officers are recognizing the value of technology assessment. Business managers view technology assessment as a management discipline allowing for the systematic determination of which technologies are most appropriate for their companies' long term objectives. The process further identifies the avenues best suited for exploiting the technologies ultimately selected. Each potential technology shift receives a rigorous appraisal and its probable degree of success is estimated by the projected margin of profit over a specific period of time.

One large corporation effectively using technology assessment procedures over the past years is the Delaware-based DuPont Company. As R&D becomes increasingly expensive, it makes sense to select new projects more carefully. DuPont is highly selective. Some areas they have targeted for concentration in the immediate future include electronics, specialty polymers, health care, and agricultural products. DuPont is cautious about straying too far away from its already proven basic skills. But, they also try to establish a long-term leadership position by selecting new product directions where there is still a considerable amount of technology to be perfected. Over the years, DuPont's technology game plan has strived to meet several key objectives: rapidity of response; sensitivity to customers; service to the marketplace; and quality.

The range of new technologies is so expansive that no single company currently in existence can hope to master them all. Technology transfer and the rapid global exchange of information means it is hard to keep a company's secrets under wrap indefinitely. DuPont was once able to boast it was virtually self-sufficient in new product generation. In recent years, they have become much more receptive to a unique blend of product development approaches including: joint ventures; purchase of equity portions in small start-up operations; government sponsored research; acquisitions; and greater user of university expertise.

Technology assessment should impregnate each of these strategies. It forces companies to digest the fact that they no longer have the luxury to say: "We have invented a new composite material, now where is the market for it?" R&D teams must pay close attention to market requirements. Technological development is expensive and the gains it produces can often prove to be quite fleeting. Without strong patent protection, and even with it, the most sophisticated technology can be outmoded quickly, almost overnight. The technology race has no finish line per se—its contenders just have to keep on running if they want to stay in the black.

IF THE TECHNOLOGY "FITS"—GO WITH IT!

Some companies have been sold on the need for strategic technology management as a result of missing an opportunity or making an investment at an inappropriate juncture. In every business setting, cost barriers are also technology barriers. Rather than repeat the error, they have sought outside expertise in the field of new technology assessment. One firm that specializes in finding the right "fit" for new technologies is Strategic Innovations International (SII) in Westport, Connecticut. SII frequently receives calls from companies whose businesses, after earning decent profits for years, have lost their pep and creative initiative.

Generally speaking, a company's lab team might develop a new product which does not directly relate to the firm's primary business ventures. Scientists tend to stand back with pride and conviction to say their new material must be good for a hundred applications! Since it is out of the ordinary, perhaps even "discovered" by accident, finding those 100 applications might be difficult, even after the company's commercial development staff and marketing wizards get into the act. If the company is determined to stick with the innovation, they might, at this point, call on the services of a firm like SII.

The method that SII uses to evaluate the technology on which the potential product is based makes use of both in-house and external resources. The service provided by SII is summarized in the following sequence of project phases:

1. An SII executive meets with a team of high-level corporate managers who represent R&D, marketing, and general management. The group reviews internal suggestions about what to do with the innovation and formulates criteria about attributes the company expects to see in the new business venture (financial goals, spending limits, manufacturing capabilities, cultural preferences, etc.).
2. SII next assembles a group of six to eight outside experts who have a useful perspective on the situation and can provide input. Without revealing the corporate client or the exact nature of the prospective new product, SII gives these panel members just enough information to get them into a brainstorming mode. At a formal meeting a short time later, they discuss the matter and are commissioned to generate a list of useful ideas.
3. Ideas from that session usually number between 50 and 80. They are brought back to the client company's management personnel who, with SII, discuss the project and try to make a critical assessment of the range of suggestions. The objective here is to evaluate the external suggestions to identify the ones that mesh well with their original criteria.
4. With a narrowed set of 5-10 ideas, SII gathers together a new group of outside specialists and goes through another evaluation and review process. By this time, the ideas are more specific, and the possibilities for success are more sharply defined.
5. At this point, SII takes the remaining ideas out to the field to conduct marketing research. They obtain data which may help to show whether any of those ideas is realistic for the corporate client.
6. The final group of suggestions and the market research report are submitted to the company's management group. It must then decide if and when it wishes to utilize any of these suggestions or drop the entire project.

Technology assessment of this magnitude takes time, but it can result in much more efficient technology management. Even if the decision is to scrap the innovation, the company may have saved hundreds of thousands of dollars in developing a product that did not sell. When corporate managers, who are in charge of technology, start to think about entering a new research area, they truly must make an honest evaluation of how their company stacks up against the competition. Further, even if a company has targeted specific areas of technology to focus on, it does not hurt to know what is happening in adjoining areas. Technology management entails technology assessment via an external technology scanning system to permit timely decisions toward effective implementation of the new technology.

TECHNOLOGY RISK ASSESSMENT

As mentioned earlier, another responsibility which falls under the jurisdiction of the technology manager is related to a procedure labeled risk assessment. At least one, if not several, facet(s) of a technology assessment study should examine the potential risks to humans if the technology is allowed to enter full scale development and production. Risk assessment is a method of studying the risks of a new technology, material, device, etc. so they may be better avoided, reduced, or otherwise managed.

Risk implies uncertainty. It follows then, that risk assessment is largely concerned with uncertainty. The related concept of probability is often hard to grasp. The effective illumination and subsequent minimization of risks requires knowing *what* they are and how *big* they are. Knowledge of this sort is commonly gained through experience over a sustained period of time. The essence of risk assessment features the application of this knowledge of both previous mistakes and deliberate actions in an effort to prevent new mistakes in new situations.

The results of risk assessments are most commonly presented in the form of an estimate of probabilities for various events that are usually injurious or dangerous. (For example, for women over 35, there is less than 1 chance in 200 that an amniocentesis procedure will result in any pregnancy complication). Although the goal of conducting a risk assessment is to obtain these types of estimates, the major value in performing a risk assessment may actually be the exercise itself. Ideally, the persons who are executing the study will explore all aspects of the action or technology under scrutiny. Refined knowledge about all angles and ramifications of the technologies will serve to make their estimates considerably less subjective.

The way we perceive various risks is strongly influenced by the manner in which they are calculated. When risk estimates are based on historical date, they are fairly easy to understand and tend to be perceived as reliable reports. Historical data provide the estimators with the frequency of events over a certain period of time—this facilitates the derivation of trends.

In order to make further predictions about the future probability of risks, researchers must employ some type of statistical model. The historical approach to estimating risks is only useful when the particular hazard has been around for a while, the risk is apparent and also large enough to be empirically measured (for example, cigarette smoking). If there is no historical database for an individual hazard in question, risk assessors may choose to consider it in separate parts. In doing so, they calculate the risks from each segment and add them together to estimate the risk for the whole system. A well-known instance where this risk assessment technique has been employed is in the calculation of the probability of a severe accident at a nuclear power plant. Some carcinogenic risks may be estimated from historical data. This process is complicated, however, by the time delay between initial exposure and the final incidence of a cancer. This is the difficult field of epidemiology where causality is very hard to prove when the risk is small or seemingly insignificant.

CAUSE & EFFECT RELATIONSHIPS

Risk assessment with regard to new technologies is a relatively young discipline. While many agencies, consulting firms, and technology managers have been performing them over the past decade and a half, there still doesn't seem to be a consensus on which basic rules and procedures to follow in order to solve problems involving risk.

The process of evaluating an environmental hazard to predict how many people may be at risk is indeed a challenge. As time goes on and we continue to develop more sophisticated detection technologies, scientists are able to measure the effect of toxic substances in smaller and smaller quantities. These assessments produce results which may actually contradict rather than reinforce the results of earlier studies. Risk analysts must take the time to follow the hazard through whatever twists, turns, and shifts it makes in the real world (refer to the DATELINE segment of this chapter; flu experts are constantly attempting to do this in order to formulate an effective vaccine). Risk assessors must be able to determine how potential threats are released into and move through the everchanging environment. Next, they have to figure out how much of the substance people might eat, breath, or swallow and then estimate how much of it they could ultimately absorb. Knowing all this, they finally make an effort to determine the severity of the hazard associated with the absorbed level of the substance.

Risk analysts rely heavily on computer modeling to get a handle on typical risk estimates. But, it is extremely difficult to incorporate all the important information into these models to make their findings reliable for the population at large. Consider the previous exercise. Even if the analysts knew exactly how much of a substance is in the environment (phase one), they can not necessarily predict how much of it people will absorb (phase two). People breath at different rates with regard to their level of exercise. Individuals possess widely disparate breathing rates and dietary habits. Each of these factors will affect the dose of specific substances taken in from food and air. People also absorb substances in varying amounts depending on the thickness of their skin and the properties of their nasal mucous. These are just a few of the discrepancies making it difficult to complete phase two of the risk assessment.

Phase three entails a determination of how much of a hazard the absorbed substance poses (will it cause acute nausea, chronic loss of hearing, etc.). This is another complicated problem. Epidemiological studies are frequently insensitive in detecting health hazards from relatively low levels of exposure. In other words, the rates of specific illnesses from a given substance must often be several times above average before analysts can conclude they are not simply random fluctuations. By definition, risk assessments are officiated to reduce the amount of risk that might be *caused* by a particular technology. But, if causation is so tricky to infer, one must wonder about the extent to which the whole activity is an exercise in futility.

ANALOGOUS RELATIONSHIPS—ANIMAL STUDIES

In cases where the epidemiological evidence is either tentative or ambiguous, risks assessors may choose to use animal studies to make their projections. Studies done by analogy suffer from their own uncertainties. Laboratory animals are commonly exposed to high concentrations of chemicals to ensure that if there are any toxic effects, they will be evident at statistically significant levels. The use of a mathematical model called a "dose-response curve" must be fitted to the resulting data to assess the probability that humans will get cancer at much lower levels than they might realistically encounter. Still, serious limitations plague the process of interpreting animal studies and extrapolating them to humans.

The initial use of high doses of toxic substances may actually interrupt the recipient's internal metabolic reactions toward the initiation of carcinogenesis. Molecular biologists have discovered the existence of certain enzymes in cells which convert chemicals to more toxic metabolites—starting the march toward cancer. When the toxic chemical agent is introduced in large quantities, the enzymes are fully occupied and can not generate the toxic by-products at a greater rate. When risk assessors extrapolate downward to realistic levels of human exposure, they generally do not take this "saturation effect" into account. Therefore, they often underestimate the risk to human beings.[2]

Another limitation is that animals and humans metabolize substances differently. For this reason, the level of the test chemical reaching various organs in the animal and the human body can differ a great deal. Subsequently, they may suffer from different health afflictions or not at all. For instance, a laboratory chemical called bis-chlormethyl ether has been found to produce nasal tumors in rats, but lung tumors in people. In other cases, dogs and humans have developed bladder cancer from some aromatic amines such as benzidine (used to make various dyes), while rodents displayed cancer of the liver. Correcting for these differences is not easy because scientists still lack critical information regarding human and animal systems across the board. Now a significant portion of risk assessment studies will rely on data accumulated through tests conducted among various animal species.

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[2] For a more detailed explanation of this limitation in the use of data accumulated through animal studies, refer to: Dale Hattis and David Kennedy. Assessing risks from health hazards: An imperfect science. *Technology Review,* May/June 1986, *89*(4), 60-71.

RISK COMMUNICATION

Technology risks are not only found in large industrial plants and hazardous waste facilities. They are also present in the air in your homes, the chemicals used by your neighborhood dry cleaning outfit, and the wood stoves found in many kitchens. Since controlling these risks has the potential to seriously disrupt individual lives and livelihoods, people insist on being more fully informed about them. They also expect to have a voice in the methods of control. Risk communication is therefore becoming more necessary but not any easier than it has ever been in the past.

Risk analysts should not attempt to overstate or understate threats, but rather to give their best estimate of its occurrence and the specific range of uncertainty. It also seems important for the various federal regulating agencies we rely on for our information to coordinate and standardize their risk assessment procedures so they will arrive at similar estimates for given technological activities.

Progress in the discipline called risk assessment has been commendable. If technology managers are to be expected to make enlightened decisions about whether or not to "go with" a new or modified technology, they must be able to operate with a reliable set of data. This expectation is predicated on improving our contemporary forecasting techniques.

FORECASTING FOR A RESPONSIBLE FUTURE

When does the future begin? Who is or should be responsible for the way it turns out? Both of these questions are central to the ongoing debates among scholars who study the future. As noted previously in the introduction segment of this chapter, the field of futures studies or futurology has grown considerably over the past several decades. The "pictures" these professionals paint of tomorrow's world illustrate a wide selection of scenarios. Some views are exciting, others are hopeful, and still others are rather grim. These images are not so much predictions of the future as they are reflections of society's contemporary concerns about the quality of life on earth.

Advertising agencies play an interesting role in future forecasting these days. They are not directly involved in the futurology profession per se. Their futuristic slogans are really created to arouse people to support their clients' products or services. However, they also seem to be making a business out of defining the future. The manner in which the essence of time is used tells consumers about the product's image with reference to the past, present, and future. Consider some of the following expressions found in a variety of contemporary advertisements:

"The future is now."
"The future is right around the corner."
"We've been working on the future for 200 years."
"We represent tradition with a future."
"Tomorrow's technology available at today's prices."
"The future is already here."

"Our products let you experience the future before its time"
"This is the wave of the future."
"Don't let the future pass you by!"

Each of these slogans implies the future is something to look forward to with a smile on your face and a positive attitude. See Figure 14.5. The statements define the future via a clear linkage with the past. They are meant to be comforting from the perspective that the future is not only going to be better, but it will also be familiar.

Present-day advertisers may be described as marketing soothsayers, but their primary objective is to sell goods. The business of technology forecasting is much more comprehensive with regard to its raison d'etre (justification for existence).

Figure 14.5 Founded in the early 1900s, this youth organization proudly displays its belief in the future course of its social agenda. Still very active in community projects, the Girl Scouts of Santa Clara County use a slogan about the future denoting an alliance with the past. (Michael Dafferner)

FORECASTING TECHNIQUES

The rise of the predicting profession of futurology has simultaneously popularized several forecasting "tricks of the trade." Three techniques which have earned respect among the futures studies community include the futures wheel, content analysis, and the Delphi study.

THE FUTURES WHEEL projection technique is a small-group brainstorming session where the participants examine the consequences of a particular social trend or a technological event. This type of activity may precede important policy-making decisions. It may also be used to format the early discussions within a technology assessment exercise. In developing a futures wheel, the group members physically prepare a visual diagram of their opinions and hypotheses about the event or trend being evaluated. Refer to Figure 14.6

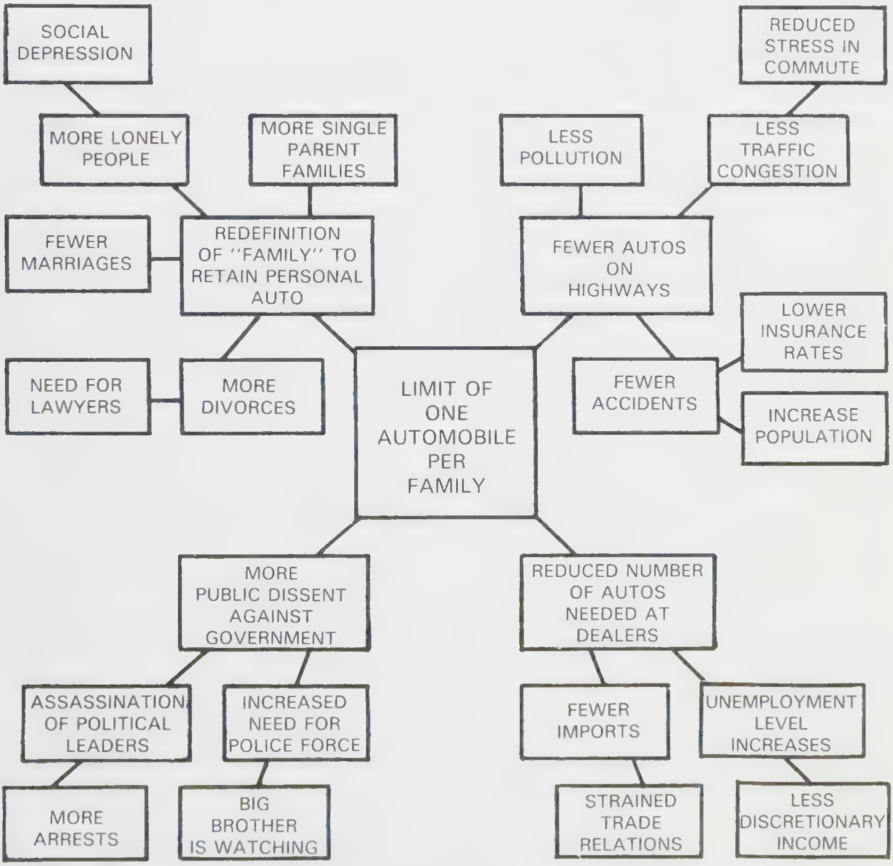
SOCIAL DEPRESSION
REDUCED STRESS IN COMMUTE
MORE LONELY PEOPLE
MORE SINGLE PARENT FAMILIES
LESS POLLUTION
LESS TRAFFIC CONGESTION
FEWER MARRIAGES
REDEFINITION OF "FAMILY" TO RETAIN PERSONAL AUTO
FEWER AUTOS ON HIGHWAYS
LOWER INSURANCE RATES
NEED FOR LAWYERS
MORE DIVORCES
LIMIT OF ONE AUTOMOBILE PER FAMILY
FEWER ACCIDENTS
INCREASE POPULATION
MORE PUBLIC DISSENT AGAINST GOVERNMENT
REDUCED NUMBER OF AUTOS NEEDED AT DEALERS
ASSASSINATION OF POLITICAL LEADERS
INCREASED NEED FOR POLICE FORCE
FEWER IMPORTS
UNEMPLOYMENT LEVEL INCREASES
MORE ARRESTS
BIG BROTHER IS WATCHING
STRAINED TRADE RELATIONS
LESS DISCRETIONARY INCOME

Figure 14.6 "FUTURES WHEEL." This is a brainstorming technique used to project probable consequences of a particular social trend, legal action, technology development, etc. (Prepared by students in "Technology & Civilization" offered in the Division of Technology at San Jose State University)

Phase one of this procedure requires the group leader to identify and describe the technology action, event, or social trend the group members are supposed to discuss. This event becomes the hub of the wheel in the diagram. Participants are asked to describe the immediate probable consequences of the trend with the proviso that any member of the group may veto any consequence perceived to be unlikely. The search is for a lineup of first-order consequences the group can agree on unanimously. Each of these first-order consequences next becomes the center of its own wheel as the group continues to make projections about second-order consequences while the veto rule remains in effect. The exercise proceeds until the wheel has expanded out to include a list of third and fourth-order consequences. This type of discussion activity enables the "experts" to review a vast selection of cause and effect relationships in a relatively short period of time. The entire list of consequences of an action, event, or trend can be further analyzed to make an educated forecast about future possibilities.

CONTENT ANALYSIS is a forecasting method where reviewers keep track of events as they occur in order to make an accurate projection of major trends 1-2 years down the road. Although it had its initial use by military strategists during World War II, content analysis has been widely popularized by John Naisbitt's Group that authors a tri-annual publication called *The Trend Report*. The premise behind content analysis is this: All you need to obtain a preview of the future is an awareness of the changes taking place right now. Companies that endorse this technology forecasting strategy are able to *reconceptualize* the nature of their own businesses in anticipation of changes taking place in the external business environment. In other words, they are not forced into quick fixes, bailouts or crisis reactions to changes for which they were not prepared.

Content analysis, as the Naisbitt Group applies it, is largely based on reading newspapers. Each day, company researchers pore over the daily newspapers of some 200 cities in the United States. They clip every relevant, local hard-news item (not wire service and not fillers), sort them into several (10-15) broad categories such as education, politics, employment, crime, etc., and then sort them again into some 200 additional subcategories.

After the news stories are categorized, two things happen. First, the number of lines devoted to each topic are counted. Since newspapers have limited space for news, if one story goes in, another must be left out. Keeping track of the changes in the amount of space allocated to each topic from quarter to quarter gives researchers a way to quantify society's changing concerns and priorities. Second, the clips from each of the broad categories are read by the same persons each month. With this amount of "topic saturation", even insignificant changes in behavior patterns can be detected through this reading exercise. Analysts who cover all of the major categories meet regularly to compare notes. It is easy to recognize that changes in one category may be related to changes in other categories. Out of all this is revealed a set of emerging trends in technology, society or whatever.

THE DELPHI TECHNIQUE process involves an anonymous exchange of opinions through an intermediary who controls the feedback of opinion in sequential rounds of interchange. The Delphi Technique has proven to be useful for long-range forecasting of technological and societal developments. Corporations and government agencies have conducted future-oriented Delphi studies dealing with topics like political affiliations, technological advancements, technology transfer, environmental degradation, medical developments, military strategy, and economic indices. When reasonable consensus had been reached, the potential events described provided a basis for subsequent planning and action. The Delphi technique is essentially designed to overcome some of the difficulties encountered when "experts" try to arrive at a consensus during face-to-face interaction in a committee meeting.

In a typical Delphi study, the participants are initially selected on the basis of their expertise or interest in a particular subject area (such as nuclear physics, meteorology, religion, education, futurology, etc.). They are sent a series of questionnaires through the mail. In the first round, for example, they might be asked to provide their *judgement* as to the probable dates of occurrence of a group of events, technology developments, or scientific discoveries (1990, 2000, 2020, after 2050, never). The responses are collated by the intermediary to reveal the spread of opinions. These data are sent back to the participants in a second questionnaire. In round two, the respondents are given the opportunity to *revise* their estimates in view of the overall group response. Respondents whose answers are either above or below the responses given by the majority are asked to *provide reasons* for their opinions. These narratives, along with the new figures of the group as a whole are collated and presented to the participants in a third questionnaire. In the third round, they are again asked to *reassess* their earlier estimates in light of the new group response profile and the reasons given by the deviants. As the study progresses to a possible fourth and fifth round, there is a convergent tendency toward a total group consensus.

Each of these forecasting techniques is reliant on the judgement and opinions of the persons involved with the exercise. The credibility of the results achieved is therefore contingent on both the imagination and technical competency of the forecasters employed. You may one day be asked to participate in a forecasting activity as part of a technological assessment, environmental impact report, or even a Defense Department planning session. Your input into such a forecast, based on careful judgement, might serve to provide a coherent structure for: testing alternative actions being contemplated, warning that certain actions are too risky and should be avoided, or defining the scope of reasonable expectations in the technological world of tomorrow. If this sounds like a tremendous responsibility, your perception is right on target.

THE TECHNOLOGIST'S RESPONSIBILITY

As time passes, science and technology are becoming less a matter of hardware and more affixed to the structure of our social network. Scientists and technologists are therefore enjoined to be responsible to the social groups wherein they operate. Where are we headed with our science and technology? Where should we be headed? Where do we go from here? Where is here? We are in the midst of a host of technological evolutions that generate much to hope for and much to fear. Tomorrow's world will present more advancements and just as many setbacks. Ten years from now, many of our current speculations will have become clear to us, but they will be replaced with a whole new set of unknowns as we move ahead in the 21st century.

A significant portion of contemporary society has become mesmerized by technology. In search of answers regarding what to do about the future course of events on their planet, social groups often look to the "experts" for guidance. In other instances, they place their trust in computerized "expert systems" for immediate solutions to long-term social and political problems. And yes, in many ways, the technologists and scientists have come to the rescue. Their contributions to humanity however present many paradoxes.

☐ We have more knowledge and information but not a lot more understanding.
☐ We have more comforts and conveniences and also more risks.
☐ We have more arms and military prowess but no greater sense of security; we have more communications technology but less community cohesion.
☐ We have more education but less appreciation of the efforts needed to secure the degrees affiliated with it.
☐ We have hundreds more choices about how to spend our time but less time to choose among them.

These realities of the day seem to make us want to ask two questions: (1) To whom do we owe our appreciation for these miraculous achievements? and (2) Who should we hold responsible for these ominous threats to our general well being and our survival?

The obvious first response to both questions is to say the persons in charge of science, technology, and engineering should be both thanked and blamed for their numerous innovations. If one delves a bit deeper however, it should become apparent that each and every person in society operates in more than one social circle and is no less responsible for the profile of the future than any other person. The social management of technological change is enmeshed in a complex network of objectives including: international cooperation, political stability, economic growth, renewed community vitality, scientific vision, technological responsibility, and a social conscience regarding the future of civilization on this planet. Regardless of educational training or technical background, every person has the unique capacity to make a contribution toward at least one of these objectives.

You have certainly had the experience at one time or another of being called upon to make an important decision affecting the lives of other people around you. Perhaps you found it necessary to "step back" away from the situation to collect your thoughts on a more objective footing before taking any action. This mental relaxation strategy illustrates the human awareness of the need to use caution when other persons' lives are involved. A short time ago, Joseph Weizenbaum, an esteemed pioneer in the field of artificial intelligence, was quoted with the following sentiment:

> What's needed more than anything else, I believe, is an energetic program of technological detoxification. We must admit that we are intoxicated with our science and technology and that we are deeply committed to a Faustian bargain that is rapidly killing us spiritually and may eventually kill us all physically.[3]

In response to the question "where do we go from here," this recommendation seems to make a whole lot of sense. Human beings have the responsibility to each other to act as leaders in society's technological research and development pursuits. Each of us must make a contribution toward the improvement of humanity's existence to bring it into accordance with both the natural environment and the technological environment.

As each of the chapters in this book has shown, responsible citizens must keep abreast of new and emerging technologies in order to intelligently determine whether or not the benefits outweigh the risks of its development. In light of the above quote, perhaps the technologist's responsibility for the future of technology excludes him or her from the luxury of "having one for the road!" In other words, decisions made "under the influence" of an overdose of faith in technology may not always be the ones most responsive to the needs and expectations of the populace. And here we are. . . .

ENDLINE

If this seems a rather ambiguous ending to an otherwise concrete presentation, you are once again quite correct in your perception. The fact is, we can *always* pick up from where ever we left off as long as we can still *find* that end point . . . And here we are! Each of the preceding chapters and this one as well presents a list of suggested readings for further study. These readings provide an excellent starting point if you are interested in increasing your understanding of technology. Perhaps they will also pique your curiosity enough that you will become committed to the construction of a responsible technological future. Stay with it!

DISCUSSION QUESTIONS

1. Explain the organizational concept known as decentralization. How can it be used to help a corporation keep abreast of technological change?
2. Where do you believe the most significant advances in leading edge technologies will take place in the next decade? Provide your rationale.
3. Identify and describe the roles and functions served by the Office of Technology Assessment. Generate a list of 5 to 10 contemporary topics or issues in technology you believe warrant their investigation. Explain why you included these topics on your list.

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[3] Long, Marion. The West Interview with Joseph Weizenbaum. *West Magazine* (supplement to the Sunday *San Jose Mercury News*), January 19, 1986, 4-5.

4. Explain what is meant by the term risk assessment. Why do people attribute a greater amount of credibility to historical risk assessments vs. those that are based on computer models? Provide examples to highlight your answer.
5. Develop a futures wheel illustrating a variety of first, second, and third order consequences related to an issue or event in contemporary science and technology.

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